STUDY REPORT
CAA-SR-81-11

INTEGRATED WARFARE REQUIREMENTS METHODOLOGY

PHASE I - FEASIBILITY STUDY

(IWRM)

MAY 1981

CONCEPTS ANALYSIS AGENCY
UNITED STATES ARMY

PREPARED BY

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CAA-SR-81-11	2. GOVT ACCESSION NO. AD-A120 880	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Integrated Warfare Requirements Methodology, Feasibility Study (IWRM)		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) COL Paul Makowski LTC Stephen J. Gamble MAJ Joseph R. Beard Mr. Charles Bruce Mr. Harold K. Graves		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Concepts Analysis Agency 8120 Woodmont Avenue Bethesda, Maryland 20014		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Concepts Analysis Agency 8120 Woodmont Avenue Bethesda, Maryland 20014		12. REPORT DATE 29 May 1981
		13. NUMBER OF PAGES 106
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ammunition rates; conventional; chemical; warhead expenditures; nuclear; theater-level; requirements data; Europe; Integrated Warfare; wartime replacement factors (WARF); methodological alternatives.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Integrated Warfare Requirements Methodology (IWRM) Feasibility Study was conducted to determine the feasibility of developing an integrated warfare requirements methodology, using currently available simulations, capable of supporting a European FY90 integrated requirements study programmed to begin in January 1983. This report provides the results of the feasibility study and culminates Phase I - Methodology Feasibility Study of IWRM.

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DEPARTMENT OF THE ARMY
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REPLY TO
ATTENTION OF

CSCA-RQN

28 May 1981

MEMORANDUM FOR RECORD

SUBJECT: Integrated Warfare Requirements Methodology (IWRM) - Feasibility Study (Phase I)

1. Reference Memorandum, CSCA-RQN, 3 November 1980, subject: Directive for Integrated Warfare Requirements Methodology (IWRM) Project.

2. In accordance with referenced tasking, the US Army Concepts Analysis Agency initiated a study to determine the feasibility of developing a near-term methodology capable of addressing integrated warfare war reserve requirements at theater-level. This was designed to be the first in a phased sequence of efforts culminating in the production of integrated warfare ammunition and wartime replacement factor (WARF) data to support POM 84-88.

3. The purpose of the attached report is to provide the results of Phase I, the Methodology Feasibility Study. Phases II and III, Methodology Development and Application, respectively, have been deferred for one year to coincide with, and support, the initial integrated warfare requirements study projected by the Director of Requirements, Office of the Deputy Chief of Staff for Operations and Plans, HQDA. In the interim, follow-on efforts will continue to update and refine the methodological alternatives presented. Questions and/or inquiries should be directed to Chief, Nuclear and Chemical Analysis Group (ATTN: CSCA-RQN), Requirements Directorate, US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20014.

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CAA-SR-81-11

CSCA-RQN 28 May 1981

SUBJECT: Integrated Warfare Requirements Methodology (IWRM) - Feasibility Study (Phase I)

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SUMMARY

1. BACKGROUND. In October 1980, a project team from the Requirements Directorate, US Army Concepts Analysis Agency (CAA) was constituted to conduct a study to determine the feasibility of combining or aggregating currently available models and methodologies to develop an integrated warfare requirements methodology (IWRM). The anticipated use of this methodology was the support of an integrated warfare excursion for the FY 84-88 POM. At that time, no decision had been made within Headquarters, Department of the Army, to task CAA for an integrated warfare excursion.

2. OBJECTIVE. After the study was initiated, the Director of Requirements, Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS), Department of the Army, deferred the consideration of integrated warfare requirements to a European FY 90 integrated requirements study with a projected study start date of January 1983. The study objective was amended accordingly.

3. METHODOLOGY. The study examined current requirements methodologies in the context of their ability to simulate an integrated warfare environment and the degree to which they could produce integrated requirements data. Alternative component models and proposed interfaces were then considered to expand the capabilities of these methodologies to the level of producing integrated requirements data. The study then grouped the variant methodologies produced to develop four sets of feasible alternative methodological solutions. Feasible alternatives were then evaluated quantitatively (i.e., for the estimated technical effort required for methodology development) and qualitatively (i.e., for their degree of satisfaction of selected criteria).

4. OBSERVATIONS

a. The development of an integrated warfare requirements methodology to support an FY 90 integrated requirements study, commencing in January 1983, appears feasible.

b. All four methodological approaches have feasible variants; however, the division level, 24-hour combat sample and the CEM/NUFAM III alternatives appear to have a more advantageous balance of quantitative and qualitative factors.

c. In light of the possibility of improvements in current simulations between the completion of this feasibility study and the initiation of methodology development, the selection of one alternative as the preferred alternative at this time would be premature.

d. the methodological approaches considered in this study are considered to be suitable interim approaches until the hierarchy of integrated warfare models envisioned under the Army Model Improvement Program (AMIP) are fully operational.

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PHASE I - FEASIBILITY STUDY
(IWRM)

CHAPTER 1

INTRODUCTION

1-1. BACKGROUND. Chief of Staff Memorandum (CSM) 80-11-21, dated 19 August 1980, in implementing the recomnmendations of the 1980 Tactical Nuclear System Program Review, tasked the US Army Concepts Analysis Agency (CAA) to develop an implementing plan and milestones for the development of wartime replacement factor (WARF) rates for the integrated battlefield. An examination of this task, in conjunction with stated and implied tasks in ongoing and anticipated CAA studies, demonstrated the need for an interim methodology capable of supporting ammunition rate, stockpile, and force structuring analyses in an integrated environment and complementing efforts to develop a method of generating integrated scenarios. This need was presented to the CAA Technical Review Board (TRB) by the Director of Requirements, CAA, on 8 October 1980 with a recommendation that a priority effort be initiated to develop an interim capability pending the full implementation of the Army Model Improvement Program (AMIP). A study directive in the form of a memorandum for Director, Requirements (Appendix B) was signed by the Commander, CAA, on 3 November 1980. At the time the study was initiated, a decision as to the inclusion of an integrated warfare excursion in the War Reserve Requirements, P-88 Study had not been made by the Director of Requirements, Office of the Deputy Chief of Staff for Operations and Plans, Department of the Army (ODCSOPS, DA). The study directive reflects CAA's best estimate of the most immediate possible application of an Integrated Warfare Requirements Methodology (IWRM) at the time the study was proposed to the TRB.

1-2. PURPOSE. The purpose of this study is to examine the capabilities of current models and methodologies in the context of developing requirements data in an integrated warfare environment and to determine the feasibility of combining their best features to develop an interim theater level integrated requirements methodology.

1-3. OBJECTIVES

a. The objectives of this study were, initially:

(1) Phase I. To determine the feasibility of developing an integrated warfare requirements methodology that will support war reserve and force structuring analyses and compute requirements for a 30-day period of integrated warfare, considering the need for:

(a) Conventional ammunition rates.

(b) Chemical ammunition rates (division level systems).

(c) Theater expenditures of designated nuclear warheads.

(d) Wartime replacement factor rates for major systems and selected notional items from five vulnerability categories.

(2) Phase II (upon approval of the feasibility study results, if feasibility is shown). To be prepared to develop an integrated warfare requirements methodology in time to support POM 84-88 with an integrated excursion of the War Reserve Requirements, P-88 Study.

(3) Phase III. To be prepared to apply the integrated warfare requirements methodology to develop integrated requirements data in support of POM 84-88.

b. During the course of the study, the sponsor of the War Reserve Requirements, P-88 Study (DAMO-RQR) determined that an integrated excursion would be premature considering the status of projects to refine the data and scenarios essential to support that effort. The tasking of CAA was deferred until January 1983. An FY 90 integrated requirements study for the European theater is presently programed as the first application of an integrated warfare requirements methodology. In view of this decision, the objectives were adjusted to:

(1) Phase I (to 2 Apr 81). Examine the feasibility of developing an integrated warfare requirements methodology capable of supporting a European FY 90 integrated requirements study commencing in January 1983.

(2) Phase II (o/a 1 Apr 82 - 1 Jan 83). Given feasibility, develop the methodology to support such an analysis.

(3) Phase III (o/a 1 Jan 83 - study completion). Apply the integrated warfare requirements methodology to determine integrated FY 90 European war reserve requirements.

c. For the purpose of this report, the principal goal is to accomplish the Phase I (feasibility study portion) objective, as restated in paragraph b(1) above.

d. In consideration of other efforts to develop integrated scenarios and integrated force structuring analyses and the possibility of unprogramed studies which may arise as weapons developments exhibit a need for stockpile or integrated requirements data, a supporting objective of this study is to develop a source of information to facilitate the simulation of integrated warfare.

1-4. SCOPE. In accordance with the guidance at Appendix B, the scope of the feasibility study was limited to the examination of methodological approaches and models applicable to the determination of theater level war reserve requirements. The study was oriented toward the use of proven methods of accumulating the effects of combat activity (i.e., combat samples, continuous combat) and high and low resolution models which have been successfully demonstrated. In the course of developing alternative methodologies for evaluation, it became apparent that the potential of the Concepts Evaluation Model (CEM) had not been fully explored; consequently, the restriction prohibiting the inclusion of CEM was removed.

1-5. LIMITATIONS

a. In conformance with the agreement at the 8 October 1980 TRB that the study effort would not require the commitment of resources of CAA directorates other than RQD, and in consideration of the need for the expeditious development of a first generation integrated requirements capability, the study team sought to restrict the alternative methodological approaches to those that had the potential for prompt development.

b. As indicated in Chapter 2, paragraph 2-2, the evaluation of methodological systems was focused on the activities of analysts in producing the components and interfaces required for methodology development and qualitative assessments of anticipated methodology performance.

1-6. CONSTRAINTS

a. Presentation of Results. The findings of Phase I (Feasibility Analysis) were scheduled for presentation to the TRB on 2 April 1981.

b. Completion Date of Written Report. As a result of the 2 April 1981 presentation to the TRB, the target date for the completion of this written report was set as 18 May 1981. At the direction of the Director of Requirements, CAA, this written report has been completed in study report format.

c. Derived Constraints. The following constraints were imposed by the capabilities, limitations, or requirements of principal data sources, external to CAA, as discussed in Chapter 2, paragraph 2-2g.

(1) The results of an ongoing qualitative research requirement are required before the current 22 conventional vulnerability categories used in the development of WARF rates can be restructured to conform to nuclear effects. This omission limits the development of WARF rates to major items and a sampling of notional minor items.

(2) Completion of AMSAA and TRADOC efforts to define the nature and magnitude of factors for the simulation of the degradation of unit effectiveness due to chemical attack is required before model modifications to incorporate these factors can be accomplished.

1-7. ASSUMPTIONS (Note: methodology development assumptions are listed in Chapter 2, paragraph 2-2.)

a. A methodology which develops integrated warfare requirements data for division level systems will be assumed sufficient.

b. A 30-day European scenario will be assumed to support methodology development (Appendix D).

c. Assume chemical weapons will be employed continuously after their initial use.

d. Assume both pulse and continuous employment of nuclear weapons in determining methodology sensitivity to scenarios.

e. Assume no effects from nuclear fallout or chemical cloud drift.

f. For the purpose of programing resources for development, assume methodology development will be accomplished by a five-man team.

1-8. DECISION PROCESS

a. Guidance. Guidance as to the quantitative and qualitative factors to be used in evaluating alternative methodological approaches is listed in paragraph 5 of Appendix B.

b. Methodology. Chapter 2 describes the traditional conventional and nuclear requirements methodologies and the derivation of the alternative methodological approaches. Appendices E through K describe the component simulations and data processors and identify points of interface for the integration of conventional, chemical, and nuclear routines. Although the methodological approaches proposed as alternatives generally involve the same high and low resolution simulations and data processors used in current conventional and nuclear analyses, they are aggregated or augmented in unique combinations that merge heretofore separate capabilities.

c. Evaluation. Chapter 3 describes the evaluation process and reports the evaluation results.

CHAPTER 2

METHODOLOGY

2-1. INTRODUCTION. The purpose of this study was to determine the feasibility of developing a methodology capable of providing requirements data in an integrated warfare environment. This was accomplished by examining candidate mixes of high and low resolution simulations and data pre- and postprocessors in the context of simulating combat in an integrated environment (Appendix D) and evaluating them in terms of their ability to produce the desired data using models currently in use within CAA (or that could be operational on the UNIVAC 1100/82 with a reasonable effort). These candidate mixes were evaluated both in terms of time and resources required for methodology development and in terms of key qualitative factors.

2-2. METHODOLOGY

a. General. The systems under examination in this study are mixtures of models (high and low resolution simulations) and data processors designed to accept scenarios, compositions of opposing forces, weapon-target engagement priorities, ammunition expenditure criteria, and tactical and strategic deployments which will portray an environment of theater level integrated warfare. They will produce ammunition rates or expenditures and wartime replacement factors (WARF) which reflected that environment (the formulae defining these data are shown in Figure 2-1). These systems were developed by analyzing the capabilities of current war reserve methodologies and models and augmenting or modifying them to develop the desired features of an integrated warfare requirements methodology. These systems will be evaluated in terms of quantitative and qualitative factors as specified in paragraph 5 of the study directive at Appendix B.

Ammunition Rate[a, b] $= \dfrac{\text{Total Rounds Fired}}{\text{Number of days in time period x avg theater TOE authorization}}$

Wartime Replacement Factor[c] $= \dfrac{\text{Total Nonrepairable Losses}}{\text{Number of days in time period x avg theater TOE authorization}}$

Theater Expenditures[d, e] = Number of rounds/warheads expended in theater during time period.

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[a]Computed for conventional ammunition by weapon (e.g., 155 HOW) and type round (e.g., HE) in terms of rounds/tube/day.

[b]Computed for chemical ammunition by weapon and agent in terms of rounds/tube/day.

[c]Computed for specified item (e.g., TANK, XM1, 120mm) in terms of losses/system/day.

[d]Computed for chemical rounds by weapon/agent.

[e]Computed for nuclear warheads by weapon/yield.

Figure 2-1. War Reserve Requirements Data

b. The Rates Generation Process. The traditional process by which conventional ammunition rates and WARF have been derived is shown in the flowchart at Figure 2-2. This process has been followed in recent requirements analyses but will be improved for the NATO 84-88 POM requirements. The improved methodology will use the Combat Sample Generator (COSAGE), a stochastic, discrete event, high resolution simulation, to replace the current mix of high resolution models (usually referred to as the AMMORATES Models) for the function of generating combat samples. Also, it will replace the Theater Rates Model (TRM) with an Ammunition Postprocessor (APP) which better employs attrition data from the Concepts Evaluation Model (CEM) in developing the equivalent stylized days used in the calculation of ammunition rates. All components of both the traditional and the improved versions were considered by the study team in this feasibility analysis. Descriptions of the AMMORATES models, COSAGE, TRM, CEM, and APP are presented in Appendices E, F, H, J, and I, respectively.

c. Conventional Requirements Model Limitations. The traditional requirements methodology uses attrition and expenditure data derived from one set of killer/victim (K/V) scoreboards to support uninterruptible 180-day conventional warfare combat simulations. When examined in the context of a type integrated warfare scenario and the considerations discussed in Appendix D, it becomes apparent that the limitations of the present models preclude an acceptable simulation of warfare in an integrated environment.

(1) CEM Limitations

(a) CEM is limited to accepting the data from one set of K/V scoreboards. A minimum of two sets (conventional/chemical and nuclear/conventional/chemical) would be required for the most fundamental integrated scenario.

(b) CEM does not have integrated logic. The model has no function to accept the predetermined criteria that would cause the execution of a nuclear pulse.

(c) CEM is not interruptible. This precludes the use of gamer interface to overcome the absence of integrated logic.

(2) AMMORATES/COSAGE Limitations

(a) There is no current capability to perform the target acquisition, fire planning, and casualty/damage assessment functions for nuclear delivery systems.

(b) There is no current capability to allow nuclear, chemical, and conventional rounds to compete for targets.

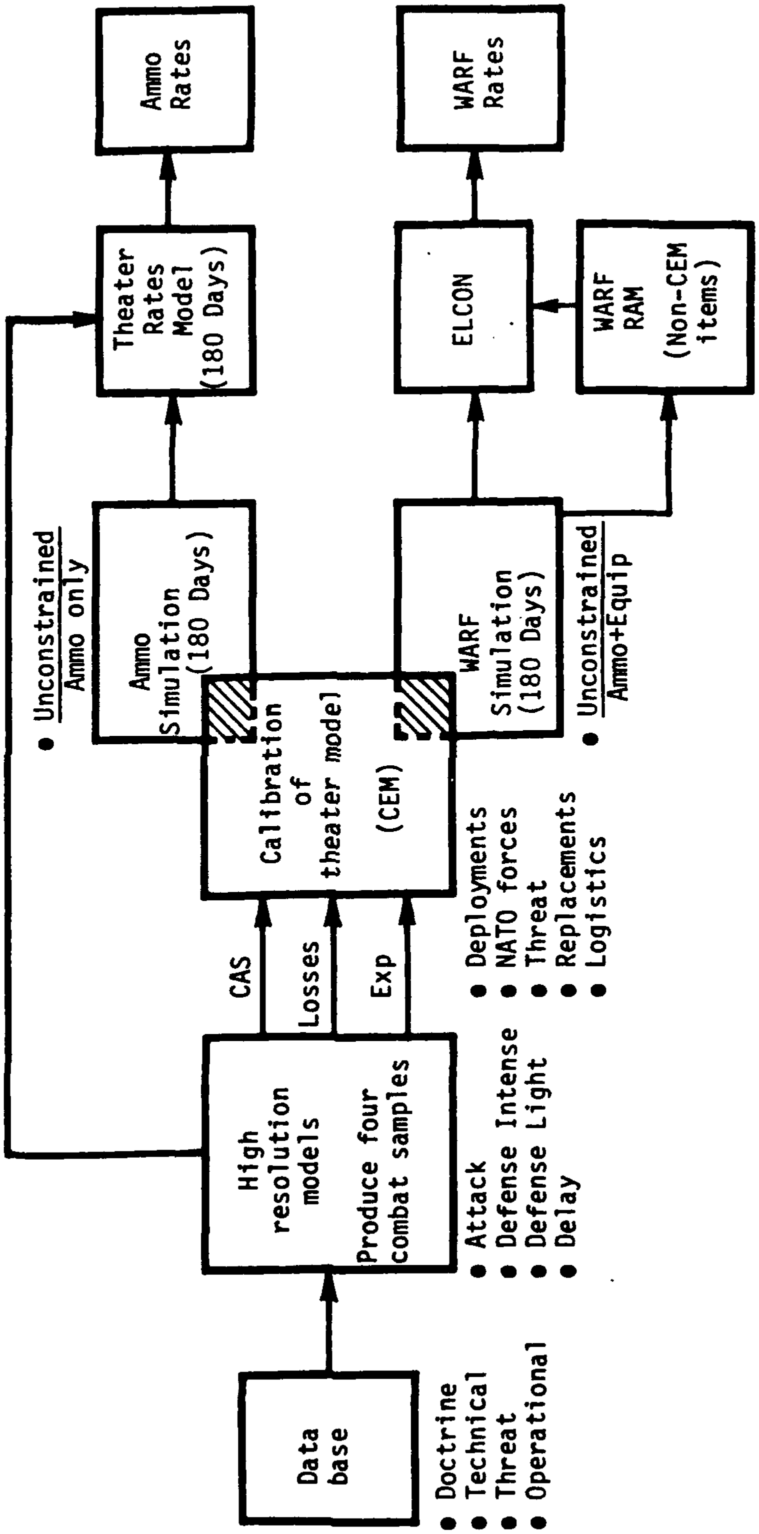


Figure 2-2. Methodology Flowchart - AMMO/WARF

(c) Stylized arrays are not compatible with the application of collateral damage criteria against a discrete population base.

(d) There is no current capability to represent the degradation of unit capabilities resulting from chemical attack.

d. The Nuclear Requirements Methodology (NUREM). The most recent CAA study generating nuclear stockpile data was the Theater Nuclear Force Requirements - 1984 Study (short title: NUREQ-84). The flowchart for this methodology is shown at Figure 2-3. This methodology will be improved by the replacement of the Nuclear Fire Planning and Assessment Model II (NUFAM II) with NUFAM III, which will incorporate a target acquisition routine previously done off-line and adds the capability of chemical fire planning and assessment. Descriptions of NUFAM and the theater level conventional war game used in NUREQ-84 (TARTARUS IV) are presented in Appendices G and K, respectively.

e. Nuclear Requirements Model Limitations. The NUREM II methodology developed a conventional warfare situation using TARTARUS IV. Upon the determination that a nuclear pulse was to be employed, the opposing forces were positioned in terrain oriented arrays, and NUFAM II was used to develop nuclear expenditure and attrition data. Conventional losses were taken from TARTARUS. Although this methodology is compatible with the majority of the characteristics outlined in Appendix D, the limitations of the models used preclude the development of required rates as defined in Figure 2-1.

(1) TARTARUS IV Limitations

(a) Conventional ammunition expenditures are provided in terms of tons/weapon category. This level of resolution is insufficient to develop ammunition rates.

(b) Equipment losses are provided in terms of overall loss per weapon category (e.g., all tanks). This level of resolution is insufficient to develop WARF rates for specific items within weapons categories.

(2) NUFAM Limitation. As used in NUREQ-84, NUFAM was applied to terrain oriented arrays. The targeting of company level subunits against specific terrain and population centers in scenarios having multiple pulses (as outlined in Appendix D) would produce an excessive operational burden.

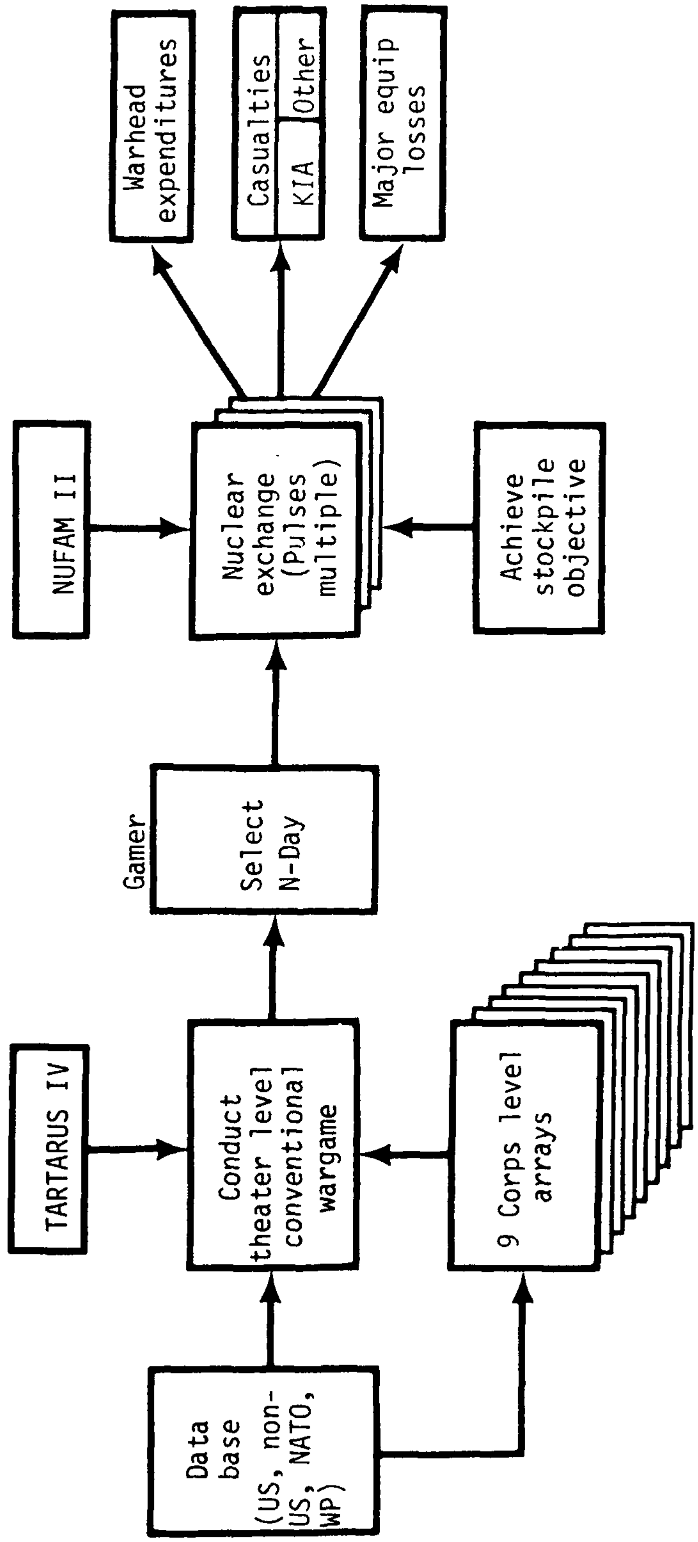


Figure 2-3. Methodology Flowchart - NUREM

f. Methodology Development Assumptions. Numerous high and low resolution simulations were examined as candidates in alternative methodological approaches which attempted to combine the best attributes of current methodologies. As the shortcomings in these current methodologies developed the need for alternative component models and modifications to the method of employing the current component models, it became necessary to assume conditions that would reasonably portray those that will exist at the time methodology development will begin.

(1) Alternative theater level simulations selected for examination would be available for production runs on the CAA 1100/82 by the time methodology development is initiated.

(2) In the absence of acceptable theater level simulations, or as an alternative to such simulations, manual war games could develop the data required to support methodology variants using the TRM for the generation of ammunition rates.

(3) CEM can be operated in successive runs to effectively produce a gamer input capability. Each run would consist of two stages: the first stage being of such duration to assure the conditions for N-day are developed, the second stage (using the same input deck as the first) of such duration as to terminate on the N-day determined in stage one for the purpose of incorporating the results of off-line integrated warfare analyses. This method of operation would require the development of a utility program to sum the expenditure and attrition data developed by the postprocessors and off-line analyses for the development of rates based on the total time period of the simulation.

(4) COSAGE will be complete (to include all second stage enhancements) and fully operational at the time methodology development is initiated.

(5) Time is available to complete modeler training, for the high and low resolution simulations chosen, before initiation of methodology development.

(6) Analyst time expended in the development of data, doctrine, arrays, and scenarios is not accountable in the category of resources expended for methodology development.

g. Relevant Constraints. The following constraints relate to the availabilty of relevant data from sources outside CAA.

(1) The development of WARF rates for the numbers of LIN items currently produced by conventional studies is facilitated by the grouping of items of equipment into 22 vulnerability categories. All items in a category have about the same vulnerability to Red conventional

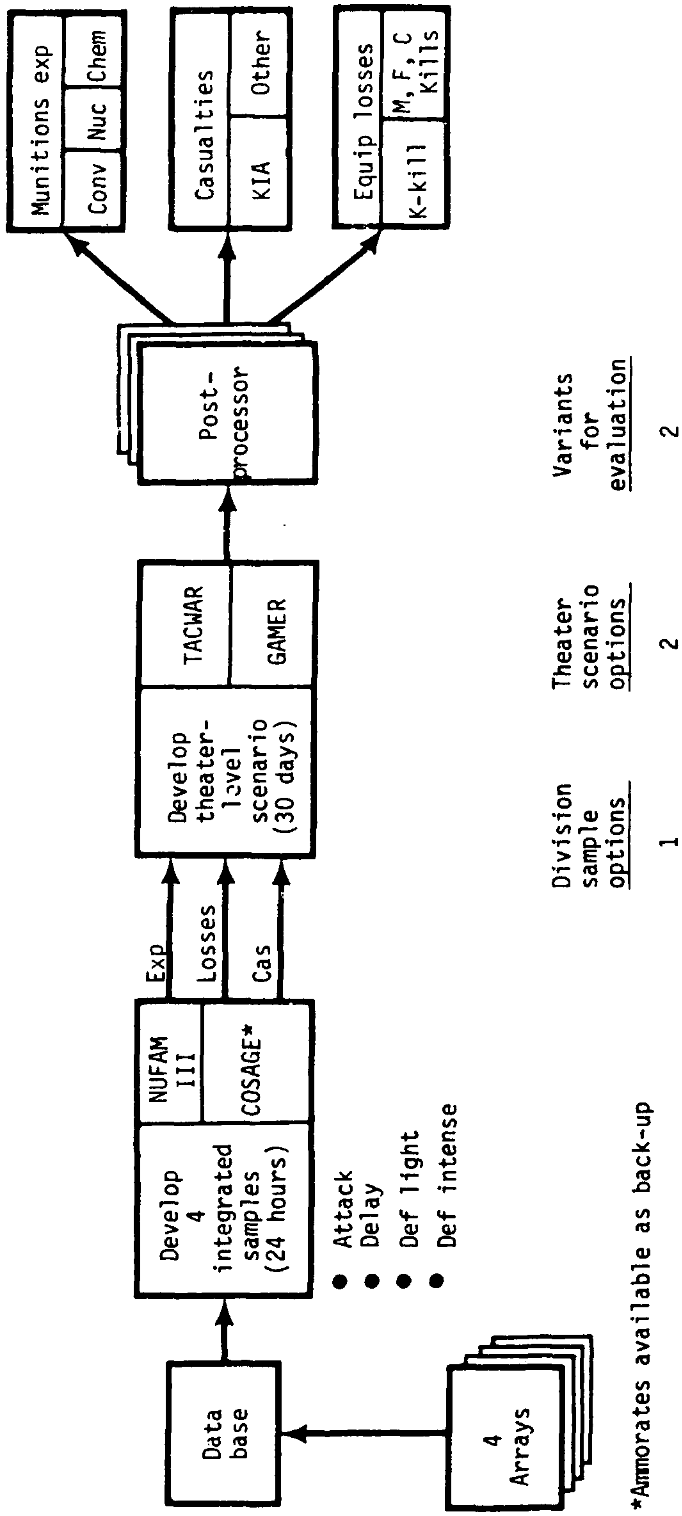
weapons in terms of lethal area relationships. The validity of these groupings when nuclear blast, thermal, and radiation effects are considered is intuitively questionable. A qualitative research requirement (QRR) for nuclear effects information was submitted to the US Army Nuclear and Chemical Agency on 21 November 1980 requesting the data to support the development of vulnerability categories compatible with nuclear effects. Until these categories are developed, the scope of WARF data provided by methodologies considered in this study will be limited to WARF rates for major items and a sampling of notional minor items.

(2) The modeling of chemical degradation factors to represent unit operations in mission oriented protective postures requires data as to the nature and degree that unit effectiveness is degraded as a function of MOPP. It is possible to simulate chemical degradation in terms of additional unit casualties, reduced movement rates and rates of fire, reductions in weapon accuracy, or through the use of barriers and terrain that produce an equivalent constraint to unit operations. It is impractical to model every factor if one predominant factor will accurately simulate the effects of chemical degradation. Until more data is developed, the modeling of chemical degradation must either be omitted or based on gross estimates. AMSAA and the US Army Chemical School have ongoing efforts to develop data in this area.

2-3. METHODOLOGICAL ALTERNATIVES

a. General. To capitalize on the potential of current methodologies, both combat samples and continuous combat type alternatives (a continuous combat methodology is one that develops actual attrition and expenditure data directly from the units gamed during the simulation on a continuous (daily) basis. This differs from combat sample methodologies which develop representative (or stylized) data by summing equivalent stylized days derived from combat samples on completion of the simulation) were selected as bases for methodology development. Within the category of combat sample methodologies, alternatives based on both division and corps level samples, of 24 and 72 hours' duration, respectively, were developed. The former was considered on the basis of decreased operation and training time and consistency with the current conventional methodology. The latter was considered on the basis of the needs to consider the interrelationships between the corps scheme of maneuver and nuclear fire planning, the extended time required for the development of corps level tactical operations, and the consideration of time lines associated with the release of nuclear weapons. In view of the ultimate development of an integrated FORCEM (the improved CEM used in the implementation of the Army Model Improvement Program has been designated FORCEM) and the strengths and potentials associated with that simulation, a CEM-based alternative was included for consideration. In all, a total of four alternative methodologies were examined, each having multiple variants according to the availability of potential component models. The alternative methodologies considered are shown in Figures 2-4 through 2-7.

b. <u>Combat Sample Methodology - Division Level 24-hour Sample (Figure 2-4)</u>. This alternative uses successive applications of NUFAM III and COSAGE to develop integrated combat samples. Two samples, one conventional/chemical and one totally integrated, were considered as a baseline for methodology development. Stylized arrays depicting Blue divisions in the traditional postures of Attack, Defense Intense, Defense Light and Delay and opposing Red forces are used in the NUFAM III model to produce integrated attrition in expenditure data. The attrited arrays are then used in COSAGE to simulate conventional combat operations, and resultant data is combined with that produced by the integrated phase to develop the integrated combat samples. Information from the integrated combat samples is provided to both the theater model and the postprocessors. High resolution attrition data is used in the theater model with force deployments along the FEBA to generate a theater scenario. This scenario provides a record of the portion of each day that the Blue force is in each of the combat postures and the level of opposing Red forces. It also determines the days on which the totally integrated combat sample will be used to depict a nuclear pulse. Theater scenario data is provided to the Theater Rates Model (the first of two ammunition postprocessors) with killer/victim scoreboards developed in the integrated high resolution simulation to produce equivalent stylized days of combat (ESD), by posture, for the development of ammunition rates by the Rates Generator Model (RGM). These ESDs, in conjunction with high resolution expenditure data, are used to compute theater expenditures when the development of rates is not applicable. Additional information as to the characteristics and functions of the postprocessors used (TRM and RGM) are provided in Appendixes H and I. Wartime replacement factor data are developed as shown in Appendix J, Figure J-1. This alternative differs from the conventional methodology in that integrated attrition data must be manually incorporated into the losses by equipment vulnerability category before combat losses by LIN item are developed as input to the Equipment Loss Consolidator. Additionally, TRM direct fire attrition data is used for the development of major item WARF. This is not commensurate with direct fire attrition data presently developed by CEM.



*Ammorates available as back-up

Figure 2-4. Division Level 24-hour Combat Sample Methodology

c. Combat Sample Methodology - Corps Level 72-hour Sample (Figure 2-5). This alternative develops an integrated combat sample using a series of high resolution division level simulations to build a Corps Level, 72-hour battle which portrays an expected mix of combat operations. A supporting 72-hour scenario and sets of Corps and division level stylized arrays are required. The scenario (gamer developed) will determine the mission and combat posture of the Corps and its divisions, by day, and determine the timing of the release of nuclear weapons. Three Corps level stylized arrays, matching the postures determined in the gamer developed scenario, are required to support the simulation. Resolution of subordinate units to company level is required for compatibility with NUFAM III. One division in each Corps array would be further defined to develop a set of division level arrays for input to COSAGE to represent the division postures determined by the scenario. The simulation would use COSAGE to develop the combat situation by division by day and produce data forthe development of a composite killer/victim scoreboard and ammunition expenditure. On nuclear or chemical days, NUFAM III would be applied prior to COSAGE gaming, and COSAGE arrays updated by the transfer of data from the Sub Unit Status File (SUSF) used with NUFAM III to the COSAGE unit files. As COSAGE is a 24-hour simulation, it does not reflect the infusion of end of day replacements and end of day changes to unit orders. Consequently, COSAGE orders and unit files must be updated before successive days of combat are simulated. The attrition and expenditure data produced during these simulations must be summed to produce a Corps Level 72-hour combat sample. The use of this combat sample is similar to that outlined in paragraph b, above, except that one mix of unit postures over a 72-hour period is used in place of the four distinct division postures. Accordingly, the scenario of combat activity and equivalent stylized days of combat would reflect variations of one posture as opposed to summing the variations of four.

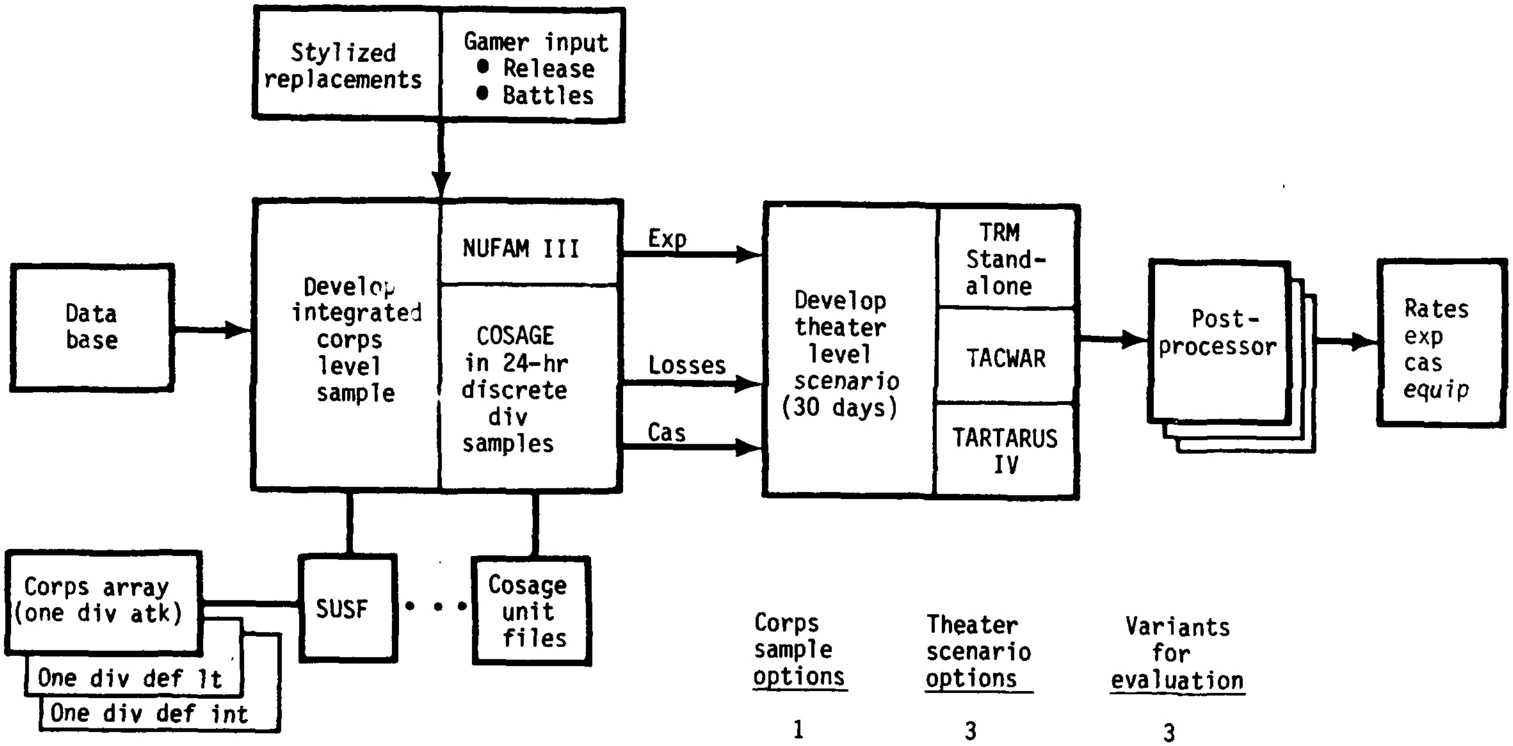


Figure 2-5. Corps Level 72-hour Combat Sample Methodology

d. Continuous Combat Methodology (Figure 2-6). This alternative is a modification of the NUREM II methodology which adds a high resolution phase to attain the degree of resolution required to produce requirements data for conventional and chemical ammunition. Corps arrays provide the force data for the theater model which, by Corps, develops the composition and posture of subordinate divisions on a daily basis. On gamer determined nuclear days, nuclear attrition and expenditure data are developed by the application of the NUFAM III model at Corps level. The attrited corps array is then examined by division to determine the best fit with a set (library) of division level combat samples. (These samples, depicting conventional/chemical warfare, are similar to those developed in the Division Combat Sample Methodology.) When a reasonable fit occurs, the attrition and expenditure data from the combat sample are used and recorded. When the closest match does not present a reasonable fit, manual computations or utility models must be used to account for the variation and develop representative data. On nonnuclear days, a match of the set of combat samples against the division unit files of the theater model is required. On the completion of each daily cycle, the attrition data is used to update the unit files in the theater model. The number of postures represented in the set of combat samples exceeds the capability of the Theater Rates Model; therefore, the development of equivalent stylized days for rates generation is not possible. This alternative requires the development of a utility model to sum the daily subtotals and perform the rates/expenditures computations.

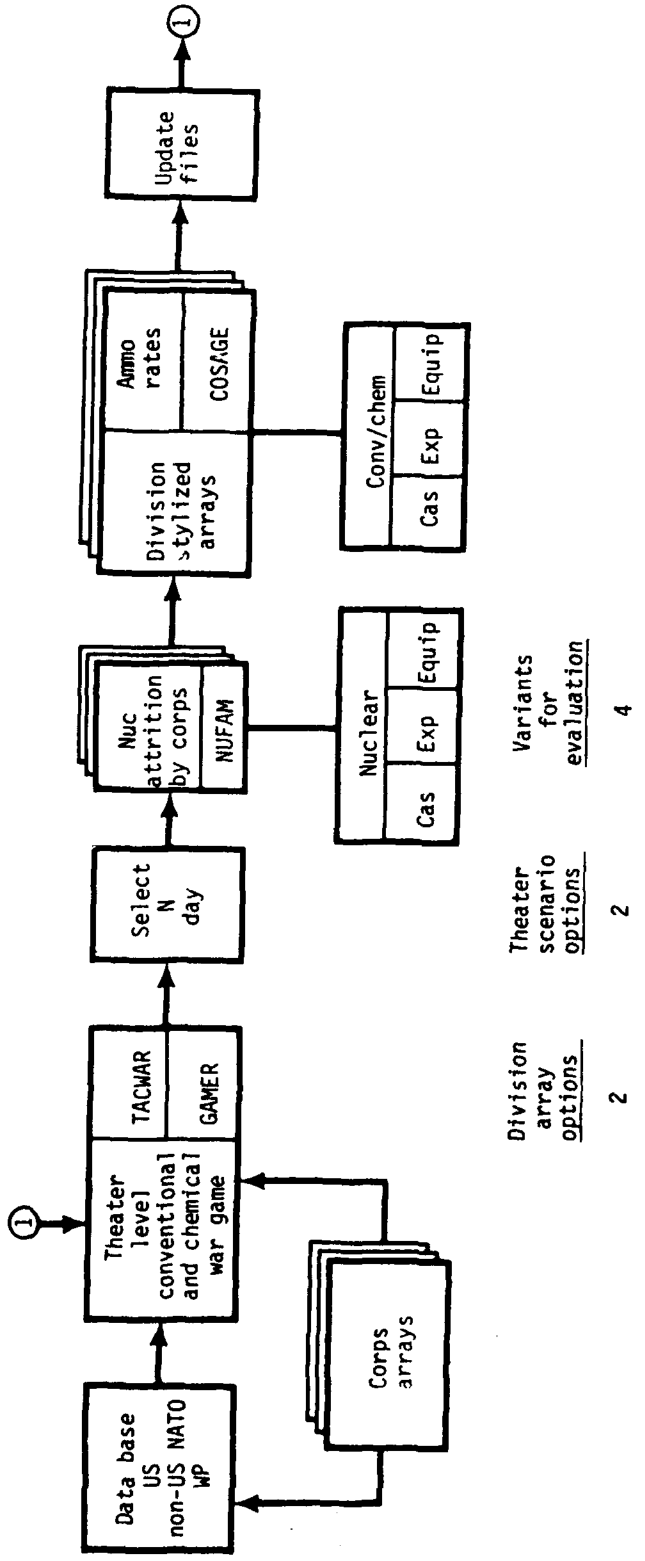


Figure 2-6. Continuous Combat Methodology

e. CEM/NUFAM III Methodology (Figure 2-7). This alternative is a modification of the conventional requirements methodology which adds an off-line analysis to determine N-days and develop nuclear/chemical attrition and expenditure data. The methodology parallels the traditional requirements methodology in the development and use of conventional combat samples to compute requirements data for US forces, but provides for the discrete representation of non-US NATO forces in the nuclear/chemical simulation with the addition of non-US arrays. The requirement to determine N-day dictates that CEM be employed in successive runs. An initial (trial) run for a designated period of time develops the status of forces engaged at the FEBA. Gamer analysis then determines the day on which the employment of nuclear weapons should have occurred. This day is then used as the end of simulation for a production run with CEM using the same input deck used in the trial run. The production run produces data for the Ammunition Post Processor and develops conventional ammunition rates in the same manner as the conventional methodology. At this point, the output from CEM is used to develop Corps arrays with resolution to company level sub units for the development of attrition and expenditure data with the NUFAM III model. Differences in doctrine and weapons capabilities attributable to non-US NATO forces are simulated by the selection of appropriate non-US arrays. Attrition and expenditure data developed with NUFAM III are recorded for subsequent integration with the conventional data. The attrition data is then used to update the unit status file in NUFAM III for the next replication of this procedure. The conventional rates produced by post processors in these segmented CEM runs must be modified by results of the off-line analysis and the subtotals from all cycles must be summed to produce final expenditure data. This can be accomplished by either manual computations or the development of a utility model.

f. Consideration of Other Models/Methodologies. As this study was oriented toward the expeditious development of an integrated methodology, initial efforts were focused on the use of components developed by, or used at, CAA. To preclude the omission of other viable candidate models and methodologies, a concurrent effort was undertaken in the form of a literature search and visits to Department of the Army (DA) and Department of Energy (DOE) facilities engaged in the development of integrated warfare doctrine, data, and simulations. A summary of simulations and war games examined and discarded as being infeasible candidates is provided in Appendix L.

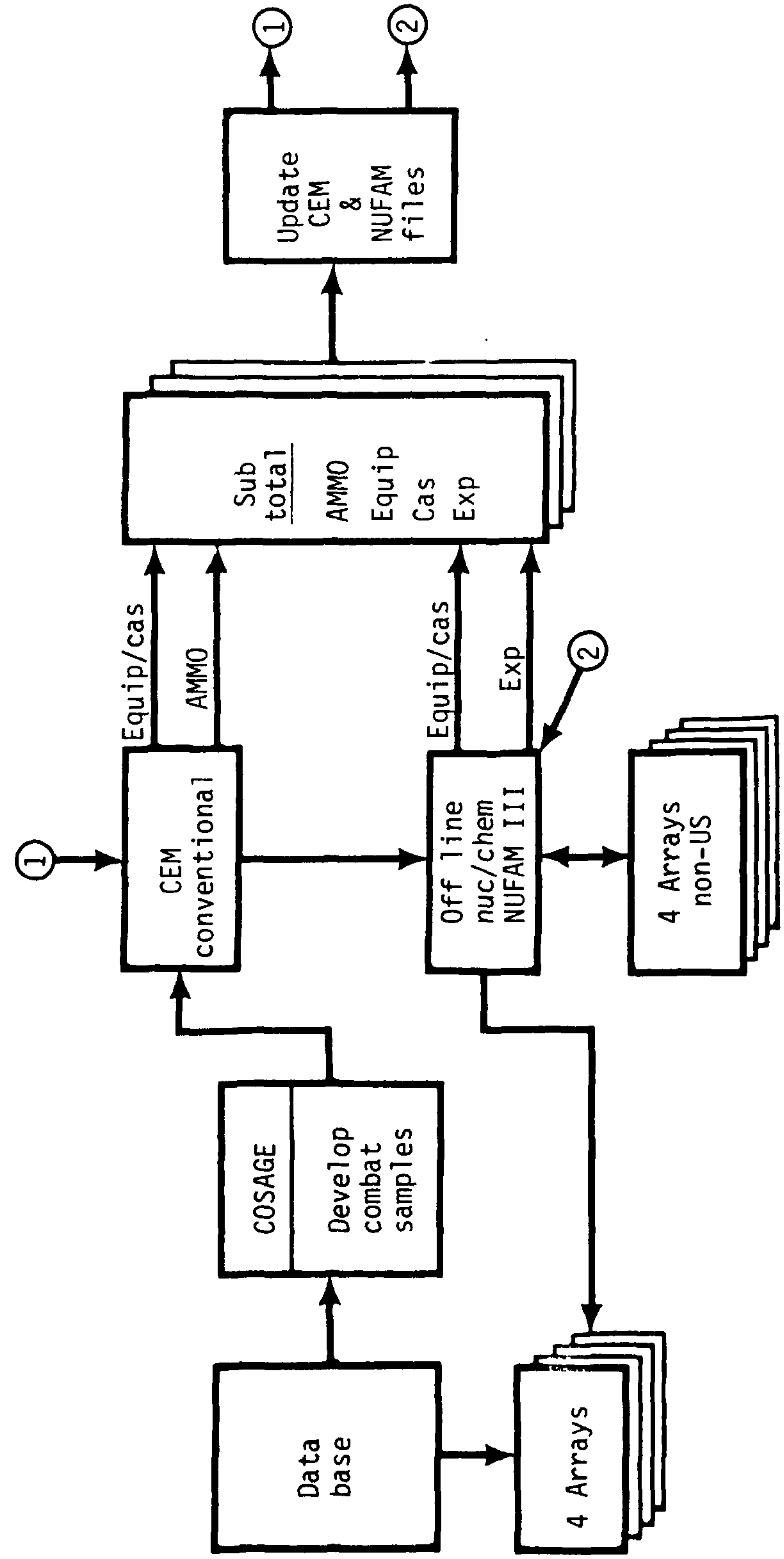


Figure 2-7. CEM/NUFAM III Methodology

g. The Alternatives. The derived alternatives are listed below in short form based on type methodology and component high and low resolution models.

(1) Division Level 24-hour Combat Sample Methodology

- COSAGE/TACWAR
- COSAGE/GAMER

(2) Corps Level 72-hour Combat Sample Methodology

- COSAGE/TRM(SA)
- COSAGE/TACWAR
- COSAGE/TARTARUS

(3) Continuous Combat Methodology

- COSAGE/TACWAR
- COSAGE/GAMER

(4) CEM/NUFAM III Methodology

CHAPTER 3

EVALUATION

3-1. INTRODUCTION. To evaluate the methodological alternatives, the time and effort in technical man-months (TMM) necessary to modify or aggregate the component models to fulfill the required integrated functions were estimated for each alternative. These estimates were keyed to the functional areas of high and low resolution modeling, the development of interfaces, and the modification of AMMO and WARF data processors. A qualitative analysis was then performed to compare the alternatives in terms of quality of data, anticipated operational burdens, and potential for future improvement.

3-2. RESOURCE REQUIREMENTS DETERMINATION

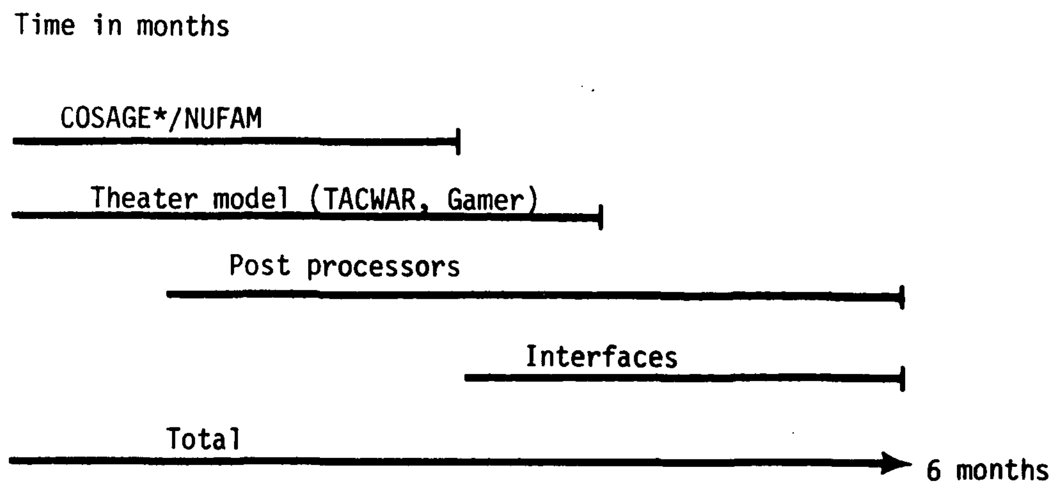
a. Criteria. The criterion of choice among alternative methodological approaches is, principally, to minimize the required technical effort (in TMM) for methodology development. On the basis of the initial study objective to accomplish methodology development in time to support POM 84-88, the study team adopted 20 TMM as a goal. The subsequent determination by ODCSOPS that an integrated excursion to POM 84-88 would be premature resulted in the withdrawal of this criterion for the determination of feasibility. The data provided in this paragraph will facilitate an assessment of the relative burden for development of the alternatives.

b. Required Resources. Figures 3-1 through 3-4 depict estimates of analytical time and effort required to complete methodology development.

(1) The top portion of each figure shows the portion of the development life cycle devoted to the functional areas specified in paragraph 3-1.

(2) The bottom portion of each figure shows, for each variant of the alternative, the number of trained personnel required and the resultant number of TMM to accomplish methodology development by functional area. Interfaces between models used to develop integrated combat samples are considered internal interfaces in the functional area of high resolution modeling and the associated TMM are accounted for therein.

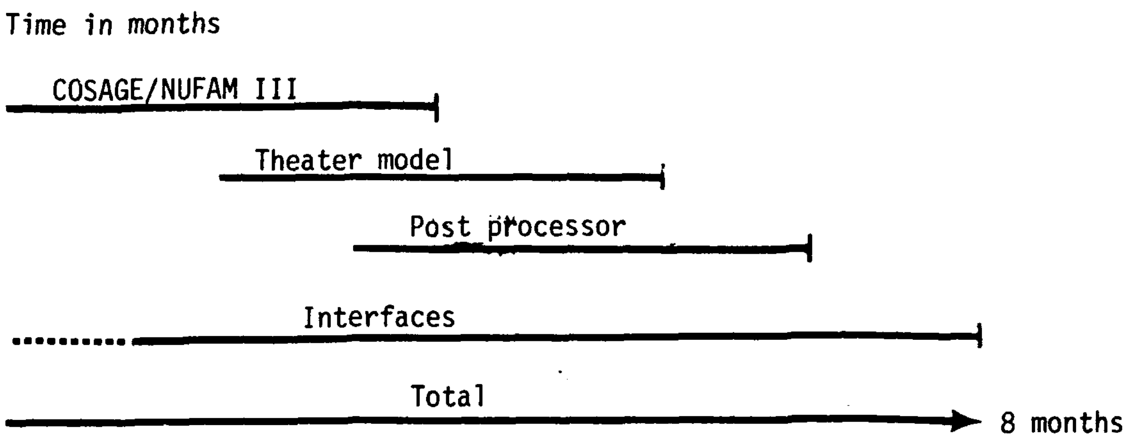
(3) In all cases, the total TMM do not include analyst time expended in the development of data, doctrine, scenarios, or arrays.



*AMMORATES available as back-up

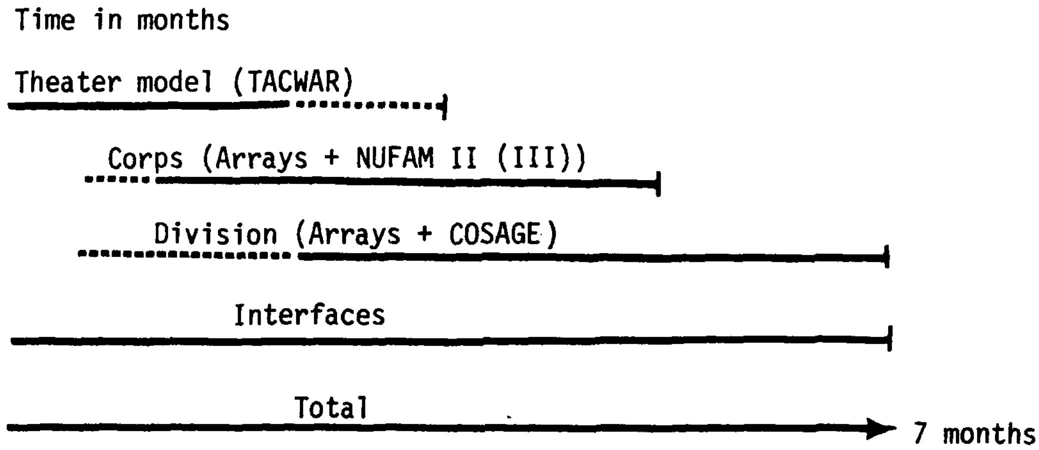
	COSAGE-TACWAR		COSAGE-Gamer	
	Pers	TMM	Pers	TMM
High resolution modeling	1.3	5.1	1.3	5.1
Low resolution modeling	1.6	6.7	1.5	6
Interfaces	---	5.4	---	4.5
AMMO	.8	3	.9	3
WARF	1.3	5	1.3	5
Total	5	25.2	5	23.6

Figure 3-1. Division 24-hour Combat Sample Alternative



	COSAGE/TRM (Stand-alone)		COSAGE/TACWAR		COSAGE/TARTARUS	
	Pers	TMM	Pers	TMM	Pers	TMM
High resolution	2.0	16	2.0	16	2.0	16
Low resolution	1.7	8	1.4	10	1.7	8
Interfaces	1.2	7.5	1.5	9.5	1.2	10.5
AMMO	0.2	2	0.2	3	0.2	3
WARF	0.4	5	0.4	5	0.4	5
Total	5.5	38.5	5.5	44.5	5.5	42.5

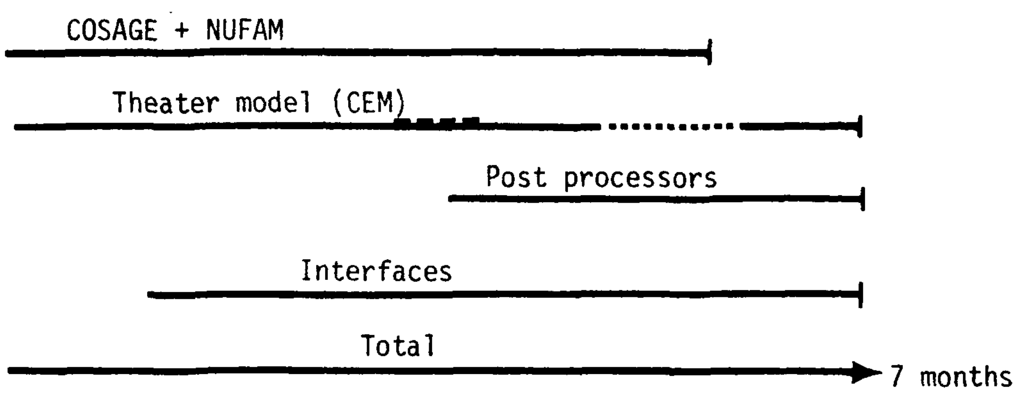
Figure 3-2. Corps 24-hour Combat Sample Alternative



	COSAGE-TACWAR		COSAGE-Gamer	
	Pers	TMM	Pers	TMM
High resolution	2.2	11.6	2.2	11.6
Low resolution	1.2	5.7	1.5	7.4
Post processor	0.7	3.0	---	---
Interfaces	---	5.6	---	5.4
AMMO	0.4	1.5	0.5	1.7
WARF	0.5	2.0	0.8	3.2
Total	5	29.4	5	29.3

Figure 3-3. Continuous Combat Alternative

Time in months



	Pers	TMM
High resolution modeling	2.5	8.9
Low resolution modeling	2.5	11.5
Interfaces	---	11.4
AMMO	1.0	2.9
WARF	1.0	2.0
Total	7	36.7

Figure 3-4. CEM/NUFAM III Alternative

(4) Estimates of operator time used to assist in or validate the modification of models are included in the TMM for the appropriate functional area.

(5) Resource and personnel estimates were based on the assumed availability of a methodology development team consisting of five personnel from the Nuclear/Chemical Group augmented by other personnel when tasks beyond their level of expertise were anticipated. For the 72-hour corps combat sample alternative (Figure 3-2), a deviation from this format to four personnel from the Nuclear/Chemical Group and 1.5 outside resources (COSAGE) would reflect a more efficient allocation of expertise for the same expenditure of personnel and would save an estimated 2 TMM.

(6) The resources devoted to high resolution modeling in Figure 3-3 were based on a moderately sized (four to eight) set of division combat samples that would serve as a basis for the refinements of expenditure and casualty data. Should a much larger set of samples be required, the process of matching this set to arrays attrited during the simulation would become tedious, and additional software development in the form of a utility program would be advisable. This would add approximately 0.5 TMM.

(7) Figure 3-4 reflects the infusion of the chemical analysis in a format (Figure 2-7) that minimizes developmental TMM but increases operational burden in the modeling of continuous chemical warfare. A variation of this alternative capable of modeling continuous chemical warfare with a significant reduction in operational burden would require an additional 2 TMM for the integration of chemical effects into the conventional combat sample.

(8) Supplementary resource requirements estimates are included in Appendices F, G, H, and J to show the nature and level of developmental effort required to integrate major component models into the alternative methodologies. These TMM are subsets of the TMM shown in Figures 3-1 through 3-4 for functional areas pertaining to the component. As they do not constitute a set of exhaustive events, their totals will always be less than the sum of the TMM from the functional areas from which they were derived.

c. Comparision of Resource Requirements. Table 3-1 summarizes the key time-effort estimates from Figures 3-1 through 3-4.

Table 3-1. Comparison of Alternatives by Resource Requirements

Factor elements	Division sample		Corps sample			Continuous combat		
	Alt A COSAGE TACWAR	Alt A COSAGE Gamer	Alt B COSAGE TRM(SA)	Alt B COSAGE TACWAR	Alt B COSAGE TARTARUS	Alt C COSAGE TACWAR	Alt C COSAGE Gamer	Alt D CEM/ NUFAM
Total development life cycle (in months)	6	6	7	8	8	7	7	7
Total personnel requirement	5	5	5.5	5.5	5.5	5	5	7
Investment (in TMM)	25.2	23.6	38.5	44.5	42.5	29.4	29.3	36.7

3-3. QUALITATIVE FACTORS ASSESSMENT

a. Criteria. The criterion of choice is the relative degree to which the alternatives satisfy selected qualitative factors.

b. Factor Selection. During the preliminary analyses leading to the development of methodological alternatives, the study team developed a list of factors which were independent of the quantitative criteria (developmental TMM) but carried equal weight from the aspect of evaluating methodology quality and utility. Next, examining only those alternatives that qualified for final analysis, the team selected those factors having the greatest apparent worth, relevance, or impact on alternative evaluation. These factors were then grouped as elements of the final four major qualitative factors. At this point, the resource requirements for methodology development were ignored, and the alternatives were evaluated independently against these qualitative criteria.

c. Assessment by Factor

(1) Table 3-2 depicts the first major qualitative factor (quality of product). This figure evaluates the methodological alternatives against their ability to produce requirements data of equivalent quality to that produced by methodologies currently in use. (Note: the Xs indicate the factor element is satisfied by the alternative considered.)

Table 3-2. Qualitative Factor 1 (quality of product)

Factor elements	Division sample		Corps sample			Continuous combat		
	Alt A COSAGE TACWAR	Alt A COSAGE Gamer	Alt B COSAGE TRM(SA)	Alt B COSAGE TACWAR	Alt B COSAGE TARTARUS	Alt C COSAGE TACWAR	Alt C COSAGE Gamer	Alt D CEM/ NUFAM
Conventional ammunition rates	X	X	X	X	X			X
Chemical rates/ expenditures	X	X	X	X	X			
Nuclear expenditures	X	X	X	X	X	X	X	X
WARF rates								X

(a) Conventional Ammunition Rates. With the exception of the continuous combat variants, all the alternatives use current procedures and postprocessors to develop conventional ammunition rates. The quality of rates produced by the continuous combat alternative is dependent on the accuracy with which arrays attrited in a simulation can be approximated by the elements of a set of combat samples. The quality of fit that can be provided by sets of the size proposed (four to eight) cannot be precisely determined; therefore, quality equivalent to that provided by current methodologies cannot be assured.

(b) Chemical Ammunition Rates/Expenditures. All the alternatives, with the exception of continuous combat, will produce chemical expenditures by the reasoning outlined in (a) above. As defined in this analysis, the CEM/NUFAM alternative produces chemical rates through off-line analysis and does not utilize the full potential of available postprocessors. This deficiency can be overcome by moving the infusion of chemical play from the off-line analysis to the high resolution simulation.

(c) Nuclear Expenditures. All alternatives use the traditional model (NUFAM) to develop nuclear expenditures. In the traditional (NUREM) methodology, that model was applied to terrain-oriented arrays. The alternatives developed for analysis in this study apply NUFAM to stylized arrays to minimize operational burdens. The move from terrain-oriented to stylized arrays presumes a probabilistic determination of mission aborts due to collateral damage criteria will produce comparable results. As this probabilistic determination has been accepted in recent non-CAA studies (using TACWAR) and is supported by observations of the NUREQ-84 study team, this presumption is accepted as reasonable.

(d) WARF Rates. The present accepted standard for WARF rates incorporates the development of direct fire attrition data from the CEM. The only alternative that meets this standard is the CEM/NUFAM alternative. The development of WARF data by the other alternatives is dependent on the acceptance of direct fire attrition data from TRM or manual operations.

(2) Table 3-3 depicts the second major qualitative factor (operational burden). Although this factor evaluates the alternatives in terms of the anticipated resources for methodology execution, it is separate and distinct from the quantitative evaluation which only considered resource requirements for methodology development. In this figure, the X's are indications that the alternative considered tends to minimize resource requirements.

Table 3-3. Qualitative Factor 2 (minimization of operational burden)

Factor elements	Division sample		Corps sample			Continuous combat		
	Alt A COSAGE TACWAR	Alt A COSAGE Gamer	Alt B COSAGE TRM(SA)	Alt B COSAGE TACWAR	Alt B COSAGE TARTARUS	Alt C COSAGE TACWAR	Alt C COSAGE Gamer	Alt D CEM/ NUFAM
Development of arrays/ combat samples	X	X				X	X	X
Development of low resolution files	X	X	X				X	
Model operator requirements	X	X	X	X	X	X	X	
Gamer requirements	X		X	X	X	X		X

(a) Development of Arrays/Combat Samples. With the exception of the corps combat sample alternative, all the alternatives use current array/modeling procedures with a proportionate increase in resource requirements for the infusion of integrated simulations. The division combat sample alternative requires two sets of four combat samples. The continuous combat alternative requires one set of four to eight samples. The CEM/NUFAM alternative uses a standard set of four conventional combat samples. The burden of developing arrays and combat samples is considered reasonable for all three alternatives. In addition, resource requirements for developing these combat samples could be minimized by incorporating work done in support of concurrent conventional studies. Although the relative magnitude of the task could not be quantified, the consensus of the study team was that a three-division, 3-day combat sample would require more resources than eight one-division, 1-day samples. In addition, a 72-hour corps sample could not capitalize on the effort of concurrent conventional studies.

(b) Development of Low Resolution Files. Based on the estimates of experienced operators, the burden of developing input files for TRM and TARTARUS was determined to be reasonable. Similar estimates from TACWAR operators determined the input files were both large and complex. The CEM/NUFAM alternative carries a significant burden in that it requires the creation of an input file after every off-line analysis (i.e., after every nuclear pulse). The absence of formal input files in gamer variants is considered advantageous.

(c) Operator Requirements. The number of CEM runs required in the CEM/NUFAM alternative (two runs per nuclear pulse) is considered a heavy operator requirement relative to the other alternatives.

(d) Gamer Requirements. Discussions with personnel participating in Scores III led the study team to conclude the operational burden of gamer variants would be excessive.

(3) Table 3-4 depicts the third major qualitative factor (flexibility). This factor evaluates the ability of the methodological alternative to respond to changes in assumptions, scenario, and data. In attempting to anticipate the potential uses of an interim integrated methodology, the study team realized sufficient variations to dictate an emphasis on flexibility.

Table 3-4. Qualitative Factor 3 (flexibility)

Factor elements	Division sample		Corps sample			Continuous combat		Alt D CEM/ NUFAM
	Alt A COSAGE TACWAR	Alt A COSAGE Gamer	Alt B COSAGE TRM(SA)	Alt B COSAGE TACWAR	Alt B COSAGE TARTARUS	Alt C COSAGE TACWAR	Alt C COSAGE Gamer	
Variations in the employment of nuclear weapons (pulse & continuous						X	X	X
Variations in the employment of chemical weapons						X	X	X
Allied use of forces nuc/chem weapons	X	X		X	X	X	X	X
Variations in scenario duration	X	X				X	X	X
Requirements for discrete collateral damage analysis						X	X	X
Chem degradation factors			X	X	X			

(a) Variations in the Employment of Nuclear Weapons. The alternative methodologies were designed against a requirement to simulate both pulse and continuous use of nuclear weapons. A scenario variation in which nuclear pulses are followed by a period of continuous use must also be considered. Methodologies which simulate nuclear employments external to the combat samples are capable of responding to any variations selected by an analyst; therefore, the continuous combat and CEM/NUFAM alternatives would successfully address this variation. Large variations in nuclear intensity over the period of the scenario are not modeled accurately by combat samples, therefore, the division and corps combat sample methodologies are disadvantaged.

(b) Variations in the Employment of Chemical Weapons. The study assumption of continuous chemical warfare after the initial employment of chemical weapons does not preclude short periods of intense chemical activity (chemical pulses). For the reasons stated in (a) above, the continuous combat and CEM/NUFAM alternatives have the potential to address this problem.

(c) Employment of Integrated Weapons by Sector. Allied participation in the employment of nuclear and chemical weapons may not coincide with the scenario followed by US forces. Political considerations may result in scenario variations where allied nations decline to use integrated warfare weapons. This requires a low resolution simulation which can partition the theater into integrated and conventional segments. This segmentation is possible in TACWAR, TARTARUS, and GAMER variations by virtue of the models' capabilities or gamer input. TRM and CEM do not have this capability; however, the off-line integrated analysis in the CEM/NUFAM variant overcomes this shortfall. TRM is the only model incapable of simulating this situation.

(e) Variations in Scenario Duration. The 72-hour corps sample alternative uses a single combat sample. Variations in the intensity of that sample are accounted for in the development of equivalent stylized days. This will produce acceptable results for scenarios of short duration, but the study team is not confident that this methodology will retain its validity for scenarios over 30 days.

(f) Requirement for Discrete Collateral Damage Analyses. Studies requiring comparative analyses of nuclear weapons by caliber/yield may require more than a probabilistic approach to collateral damage. Such studies would be best served by the use of terrain-oriented arrays. Division and corps level combat sample methodologies, which use stylized arrays, would not be responsive to this need.

(g) Simulation of Chemical Degradation. The simulation of degraded unit effectiveness after chemical attack is dependent on the intensity of combat and the duration of operations in mission oriented protective postures. A 24-hour sample does not provide sufficient simulation time to reflect the cumulative effects of these factors. The

72-hour corps combat sample alternative is the only alternative that satisfies the need.

(h) The comparative analysis presented to the CAA Technical Review Board on 2 April was oriented toward three factors: simulation of allies, nuclear partition of the theater, and collateral damage. These factors are discussed in subparagraphs (c) and (f) above. Questions and discussions during the conduct of the TRB led to the subsequent incorporation of two factors that were discussed (but not tabulated as factor elements of the major factors) as factor elements in the analysis of flexibility of methodology. These factor elements are variation in scenario duration ((e) above) and the simulation of chemical degradation ((g) above). A review of the study results to ensure all methodological alternatives were evaluated against the capability to simulate both nuclear pulses and the continuous employment of nuclear weapons discovered the possibility of mixed modes had not been addressed. The team determined that possibility was relevant to scenario variations for both nuclear and chemical weapons and it was incorporated in the form of two additional factor elements as outlined in subparagraphs (a) and (b) above. The net result of these additional factor elements was a weakening of the COSAGE-TACWAR and COSAGE-TARTARUS variants of the Corps sample alternative. The team determined the relative weight of favorable factors (simulation of allies, nuclear partition of the theater, and the capacity to simulate unit degradation over time after chemical attack) was sufficient to sustain the favorable rating of those variants.

(4) Compatibility with Future Developments. Alternative methodologies were evaluated in terms of their potential for future development. The two main considerations in this evaluation were the adoption of COSAGE in the conventional requirements methodology and the compatibility of the alternative methodologies with the development of integrated high and low resolution simulations in the Army Model Improvement Program (AMIP). As CEM will serve as the parent of the AMIP FORCEM, it holds the advantage in this evaluation. The study team originally included all COSAGE variants on the basis of compatibility with future conventional methodologies and the potential for COSAGE's inclusion as a candidate for a high resolution model in AMIP. A reevaluation of the gamer variants determined they would not contribute to the development of a system for high-low resolution simulations with dynamic interfaces, and they were eliminated.

d. Comparison of Qualitative Factors. Table 3-5 summarizes the qualitative evaluations discussed in paragraphs 3-3c(1) through (4) by major factor.

Table 3-5. Summary of Qualitative Factor Analysis

Factor elements	Division sample		Corps sample			Continuous combat		
	Alt A COSAGE TACWAR	Alt A COSAGE Gamer	Alt B COSAGE TRM(SA)	Alt B COSAGE TACWAR	Alt B COSAGE TARTARUS	Alt C COSAGE TACWAR	Alt C COSAGE Gamer	Alt D CEM/ NUFAM
Quality of results	X	X	X	X	X			X
Minimize operating burden	X					X		
Flexibility				X	X	X	X	X
Compatibility with future developments	X		X	X	X	X		X

3-4. TECHNICAL RISKS. The minimization of technical risk was originally considered as a major qualitative factor. In considering the nature of the methodological alternatives, the study team determined no alternative to be free from technical risk and that factor ceased to be a discriminator. To ensure the consideration of these risks is not overlooked; they are included below:

a. Consistent attrition in low resolution simulations in the COSAGE/TACWAR and COSAGE/TARTARUS variants is dependent on calibration (see Appendix L). The study team concluded acceptable calibration requires some methodology development. The risks associated with these variants are:

- Less than desired precision in calibration

- Excessive variations from TMM estimated for low resolution model development

b. The CEM/NUFAM alternative will integrate unit attrition from the off-line analysis through the CEM unit status files. Unit status is presently represented as a percentage of authorized personnel and equipment. The heavy attrition of a particular major item may not be accurately represented. Consultation with CEM programers has led to this being categorized a solvable problem. Some developmental work is required to assess the degree of modification required in this file to accept an accurate representation of off-line attrition data. The technical risks associated with this alternative are:

- Unrefined unit attrition after nuclear pulses

- Unforeseen requirements for model modification

c. The continuous combat variants attain the resolution required to produce conventional and chemical ammunition data by the variation of data produced from a set of combat samples. Some developmental effort is required to verify the adequacy of what is projected (four to eight) as a reasonable set of reference combat samples. The technical risk associated with these variants is:

- Inadequacy in size of the set of reference combat samples

d. The 72-hour corps combat sample alternative uses a single combat sample. Although variations in unit attrition and opposing forces data will provide for the flexible application of that sample in the development of equivalent stylized days for rates generation, the rates produced may not have the required sensitivity to variations in input data. The technical risk associated with these variants is:

- Insensitivity to variation in data

CHAPTER 4

OBSERVATIONS, RECOMMENDATIONS, AND FOLLOW-ON EFFORT

4-1. OBSERVATIONS

a. The development of an interim integrated warfare requirements methodology appears feasible.

b. All four of the methodological alternatives considered have feasible variants.

c. Considering both the projected resource requirements for methodology development and the results of the qualitative evaluation, the division level 24-hour combat sample methodology and the CEM/NUFAM III methodology appear preferable alternatives.

d. Phase II of this project (methodology development) is oriented toward a projected European FY 90 integrated requirements study scheduled to begin in January 1983. The selection of a preferred alternative before initial coordination for tasker development would be premature.

f. Further feasibility testing of procedures to calibrate TACWAR and TARTARUS to the results of high resolution simulations is needed to validate their capacity to produce consistent low resolution attrition.

g. Further feasibility testing of routines/modifications required to infuse the results of off-line nuclear attrition into the CEM unit status files is needed to develop insights as to the acceptability of results and the level of model modification required.

4-2. RECOMMENDATIONS

a. Formal implementation of Phase II should be programed no earlier than 1 May 1982.

b. CAA should cohost with ODCSOPS-RQ, DARCOM, and TRADOC a series of data validation seminars in the January-March 1982 timeframe to update existing modeling data and expand the data base to address the technical effects of, and warfighting in, an integrated warfare environment.

c. The Integrated Warfare Requirements Methodology (IWRM) project should be maintained at 2 technical man-months per month until January 1982 to monitor and incorporate ongoing model/methodology developments and provide a nucleus for a study team which could react to short notice, limited objective integrated warfare study requirements.

d. Further low priority feasibility testing should continue as part of the 2 technical man-months per month effort to diminish the degree of technical risk in the alternative methodologies and identify data and model modification related efforts which will support integrated warfare studies at CAA and facilitate the implementation of Phases II and III of this study.

4-3. OUTLINE OF FOLLOW-ON EFFORT

a. General. The following is a summary of follow-on effort proposed to be conducted or coordinated by the CAA project officers between completion of this feasibility study report and January 1982.

b. Follow-on Effort

(1) Monitor the progress of component models still under development.

(2) Conduct further feasibility testing of procedures to calibrate TACWAR and TARTARUS to the results of high resolution simulations.

(3) Participate in feasibility testing of routines/modifications to infuse off-line integrated attrition into the CEM unit status file.

(4) Monitor AMSAA and TRADOC efforts to develop factors for the simulation of the degradation of unit effectiveness resulting from chemical attack.

(5) In conjunction with (5) above, support efforts to modify CAA models to accept these factors, when produced.

(6) Contrive to participate in efforts with other Army agencies to develop data to represent the effects of theater level nuclear/chemical weapons on support forces and the resulting influence on the FEBA battle.

APPENDIX A

STUDY CONTRIBUTORS

1. STUDY TEAM

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Mr. Edward P. Kerlin, Institute of Defense Analysis (IDA)
Mr. L. Bruce Anderson, Institute of Defense Analysis (IDA)
Mr. Ronald Rhodes, CACI
Mr. Timothy Himmelhaber, Chemical Systems Laboratory
Mr. Donald Blumenthal, Lawrence Livermore Laboratory
Mr. James Struve, Sandia Livermore Laboratory
Ms Martha Moody, Combined Arms Studies and Analysis Activity (CASSA)
MAJ Ronald Taksar, Combined Arms Center Development Activity
MAJ Harold Rubin, Field Artillery School, FT Sill, OK
Mr. Richard Stratton, Sandia Albuquerque Laboratory
LTC Wyatt Colclasure, Chemical School, FT McClellan, AL
LTC Victor Letonoff, HQ TRADOC
MAJ Douglas Schultz, Chemical School, FT McClellan, AL

3. PRODUCT REVIEW BOARD

Dr. Alan E. Johnsrud, Methodology and Computer Support Directorate
LTC Dennis F. Roerty, Joint Forces and Strategy Directorate
Ms Ola C. Berry

APPENDIX B

STUDY DIRECTIVE

CSCA-RQN 3 November 1980

MEMORANDUM FOR DIRECTOR, REQUIREMENTS

SUBJECT: Directive for Integrated Warfare Requirements Methodology (IWRM) Project

1. Purpose: To develop an interim theater-level requirements methodology that will portray the integrated employment of conventional, chemical and nuclear munitions.

2. Background: The Department of the Army depends upon CAA to produce theater-level requirements for ammunition, materiel and personnel to be used as a basis for identifying the Army's future needs in annually published Program Objective Memorandum (POM). To date, conventional, nuclear, and chemical ammunition requirements have been computed separately, using differing scenarios and methodologies. Materiel and personnel requirements have been based on conventional warfare alone. Recent actions and events indicate that CAA will be tasked to produce ammunition, materiel, and personnel replacement requirements to support operations in an integrated environment. A requirement exists to develop a near-term methodology capable of addressing integrated warfare requirements at theater-level. Time constraints dictate that existing models and methodologies will be exploited in-so-far as possible to form the framework of the integrated warfare requirements methodology.

3. Project Sponsor: Commander, US Army Concepts Analysis Agency.

4. Project Proponent: Requirements Directorate, US Army Concepts Analysis Agency.

5. Terms of Reference:

a. Problem. The Army lacks a requirements methodology to address theater-level war reserve needs in an integrated warfare environment. Until the full implementation of the Army Model Improvement Program (AMIP) is realized, CAA needs an interim capability to assist Department of the Army decisionmakers in analyzing emerging issues, including doctrine, tactics, force structure, materiel development, and resource requirements, in an integrated environment. This project is designed to determine the feasibility of developing an interim capability.

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SUBJECT: Directive for Integrated Warfare Requirements Methodology (IWRM) Project

b. Objectives.

(1) Phase I - Define the theater-level characteristics of a methodology that would produce representative war reserve requirements in a hypothetical integrated warfare environment. Determine the feasibility and utility of augmenting, aggregating, or modifying current war reserve models and methodologies to fulfill this interim role. Determine the effort required to support the 84-88 POM with an integrated warfare excursion capability.

(2) Phase II - Develop the interim theater-level integrated warfare requirements methodology to support the 84-88 POM.

c. Scope. This project is limited to the determination of theater-level war reserve requirements, expressed either as stockpiles, or as expenditure rates, depending upon the specific item of interest. The study will examine the current methods of accumulating the effects of combat activity (i.e. stylized days; continuous combat), the type and duration of that activity (i.e. 24 hours; 72 hours), and other scenario-combat simulation interfaces. Recent work ongoing in the CACDA SCORES III integrated warfare analysis will be reviewed to determine its applicability and suitability as a high-resolution data base to support theater model calibration. In the near-term, potential sources of theater-level scenarios to be examined include gamer judgment, the Theater Integrated Warfare Scenario Study (TIWSS), the TACWAR Model, and the Theater Rates Model (TRM) in a stand-alone mode. The Concepts Evaluation Model (CEM) is not considered to be a viable, near-term alternative.

d. Limitations. As this project is key to the development of an interim solution, only near-term models, methodologies, and capability for analysis will be considered in Phases I-II.

e. Constraints.

(1) Funds and resources are constrained as described within this directive.

(2) Project results will be made available and reports published in accordance with schedule in paragraph 9f.

f. Time Frame: FY 1988.

g. Assumptions. To be developed as needed to support methodology development.

h. Essential Elements of Analysis (EEA).

(1) Phase I.

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(a) What are the essential components and features of both adequate and accurate methodology for integrated warfare requirements methodology?

(b) What essential components and features of a good methodology are lacking or deficient in the present methodologies?

(c) What are the time and level of effort requirements for improving on present methodology?

(d) Which of the indicated improvements could CAA undertake within the time constraints of the project?

(e) What assumptions are key in present and expanded methodologies? Are they valid based on current and future trends?

(f) Will the integrating features and improvements permit the development of a valid integrated warfare requirements methodology?

(g) Are the initiation of data collection and doctrine monitorship sufficient to insure timely implementation of the methodology?

(h) What is the growth potential of this methodology, or what alternatives should be considered for later use?

(2) Phase II. To be determined.

i. Environmental/Threat Guidance.

(1) Scenario and threat to be determined.

(2) The threat guidance will be as directed for P88 from direct coordination with OACSI for future implementation of methodology.

(3) No environmental consequences are envisioned; however, the study agency is required to surface and address any environmental considerations that develop in the course of the study effort.

6. Specific Tasks and Schedule: See CAA Form 59 at Inclosure 1.

7. Resources:

a. Manpower: Phase I - 7.7 Technical Man Months
Phase II -16.6 Technical Man Months

b. Computer Time: Approximately 30 hours.

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SUBJECT: Directive for Integrated Warfare Requirements Methodology (IWRM) Project

8. Responsibilities:

a. Project Director. Colonel Paul Makowski.

b. Directorate. The Requirements Directorate will provide overall direction of the project effort and will support coordination with the OACSI Red Team, CACDA, USANCA, Livermore Laboratories, the Chemical School, and other agencies.

9. Administration.

a. Project Title: Integrated Warfare Requirements Methodology (IWRM).

b. Completion Date: Phase I - 31 January 1981
Phase II - 31 July 1981 (If approved)

c. Control Procedures. The Commander and the Technical Director will provide command direction and executive guidance.

d. In-Process Review (IPR). IPR will be conducted for the TRB.

e. Study Results. Project results will be reported in a technical paper for distribution to users.

f. Milestone Schedule.

(1) Phase I (Concepts Methodology Definition) initial results provided by 31 January 1981. The TRB will be briefed, and recommendations regarding continuation into Phase II will be provided.

(2) Phase II (Development and Implementation) results will be provided by 31 July 1981.

1 Incl
as

EDWARD B. ATKESON
Major General, USA
Commanding

PROJECT SCHEDULING REPORT

PROJECT TITLE (NUMBER)	Integrated Warfare Requirements Methodology (IWRS)

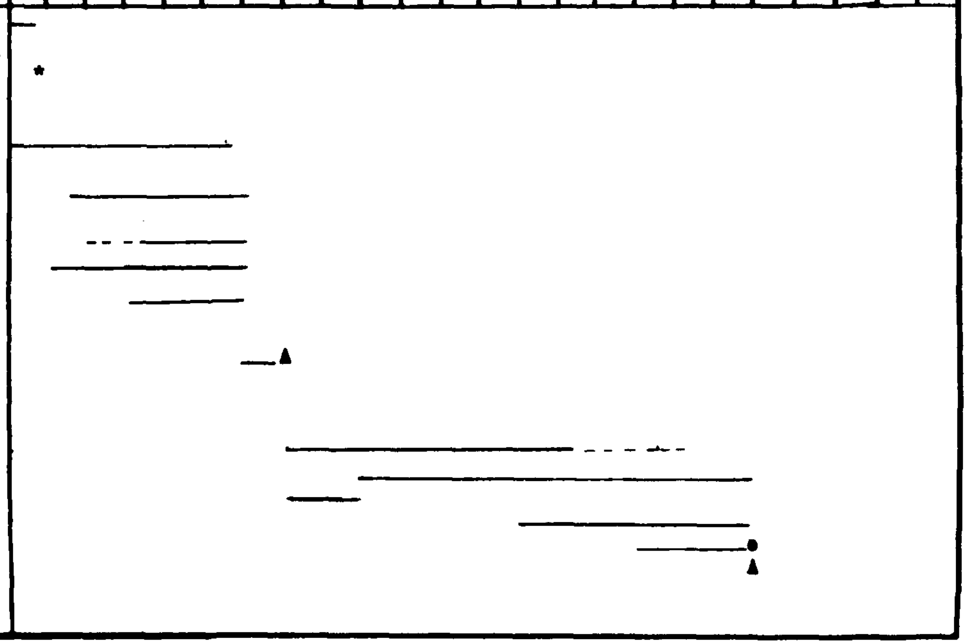
SPONSOR: USACAA
POC: COL Paul Makowski

FORM SUBMISSION DATE
INITIAL: 22 Oct 80
REVISED:

PROPONENT DIRECTORATE: RQ
PROJECT DIRECTOR: COL Makowski

SUPPORTING DIRECTORATES
JF, MC

STARTING DATE: 1 Nov 80
COMPLETION DATE: 31 Jul 81

PROJECT TEAM MEMBERSHIP	EVENTS	SCHEDULE (Months) MILESTONES (✱ - Critical Point, △ - Briefing, ● - Product Submission) Nov Dec Jan Feb Mar Apr May Jun Jul
GA REP: MAJ Beard EDITOR: Mr. Bruce OTHER MEMBERS: LTC Gamble, Mr. Graves, Mr. Stevens	COORDINATE DRAFT DIRECTIVE APPROVAL OF DRAFT DIRECTIVE BY CAA COMMANDER Phase 1 Review alternative methodologies Develop IWRM features Initiate data collection Monitor doctrine Scenario development Analyze alternatives Phase 2 Refine/develop --methodology --arrays Integrate scenario User training Test methodology	

DIRECTORATE	PROGRAMED RESOURCES (TMM) MONTH (Beginning with month Commander approved draft directive)																								TOTAL TMM BY DIRECTORATE	TOTAL TMM
	N	D	J	F	M	A	M	J	J																	
RQ	2.6	2.5	2.6	2.8	2.8	2.8	2.8	2.7	2.7																24.3	
JF-TBD																										
MC-TBD																										

1. **SUPPORTING DIRECTORATES AND TYPE OF SUPPORT PROVIDED**

   MC - Modeling support
   JF - TIWSS

2. **MODELS REQUIRED** (List name, model number*, and estimated CPU hours)

   To be determined

3. **OTHER** (Contract, other government agency, etc.):

   Coordination as required

* Model numbers controlled and assigned by Modeling Group, MRCB

APPENDIX C

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APPENDIX D

INTEGRATED WARFARE/SCENARIO STUDY CONSIDERATIONS

D-1. GENERAL. The characteristics of an integrated environment present unique challenges to the accurate representation of combat in both high and low resolution simulations. To ensure the adequacy of methodological alternatives, the study team examined this environment and developed considerations to be used in evaluating the capabilities of candidate mixes of high and low resolution models to simulate the conduct of integrated warfare (IW).

D-2. INTEGRATED WARFARE/SCENARIO CONSIDERATIONS. The following considerations were developed by the study team for the evaluation of candidate mixes of high and low resolution simulations. A 30-day European IW scenario was assumed to establish a basis for reference.

a. Decision to Employ Nuclear and Chemical Weapons. The decision to use nuclear and/or chemical weapons on D-day may be specified before the beginning of combat simulation. After D-day, the decision to use IW weapons must follow from the development of the tactical situation and the application of predetermined rules or criteria for such employment. An integrated methodology must include either a low resolution model with integrated logic or a model that has the capability of gamer interface.

b. Degradation of Deployment Schedules. The attack of ports, airfields, POMCUS storage sites, and the degradation of intertheater road and rail networks will affect the movement of deploying units to the FEBA. The timing and effectiveness of these attacks, if they occur after D-day, become a function of the dynamic situation and the capabilities of opposing forces. An integrated methodology must account for these factors through routines in the low resolution model which apply degradation factors or through a dynamic gamer-model interface.

c. Non-FEBA Losses. Conventional requirements methodologies develop detailed combat losses at the FEBA through the aggregation of data developed through high resolution modeling. Non-FEBA losses from conventional weapons, although accounted for by the application of gross computations or off-line analyses, are unacceptable for the development of integrated ammunition and wartime replacement factor rates. Low resolution models could account for these losses through:

(1) Model logic which dynamically attrites units behind the FEBA.

(2) Gamer interfaces.

(3) Development of a low resolution model which will accommodate a second set of large area stylized arrays to game non-FEBA units.

d. Employment and Attrition of Theater Nuclear and Chemical Weapons. Long-range nuclear and chemical weapons (including air) can be gamed in low resolution models. In this case, the employment of these weapons against a mix of deep and FEBA targets dictates a high-low resolution interface. Until the full implementation of the Army Model Improvement Program, gamer interfaces with fire planning and assessment models capable of incorporating the effects of air and long-range weapons into division level exchanges will be required to fulfill this function.

e. Posture of Forces. Units will adopt a variety of postures as they pass from conventional to phases. The methodology should be capable of portraying all significant changes of posture. This is both a high and low resolution problem as it includes arrays, movement rates, rates of fire, and other data used in both levels of modeling. Table D-1 outlines major factors causing variation in unit posture.

f. Terrain and Barriers. The effects of these considerations are significantly magnified in the simulation of integrated warfare.

(1) The contamination of terrain and barriers with persistent agents will impede unit movements.

(2) Nuclear weapons used against choke points will degrade unit deployments and resupply operations.

(3) Low terrain coupled with low temperatures will significantly increase the persistency of volatile agents.

Table D-1. Variations in Unit Posture

Physical factors
• Units are not dispersed in conventional warfare. They will be dispersed in nuclear or "nuclear scared" postures
• Frequent and rapid transitions from dispersed to conventional postures will be required to conduct combat operations
• Physical location of nuclear capable systems and elements considered to be priority nuclear targets will deviate from standard
Effectiveness factors
• Units in chemical mission oriented protective posture (MOPP) will be less effective due to degraded movement rates, ratio of fire, and accuracy of fire
• Unit effectiveness will be degraded by the presence of latent lethal casualties
• The accumulative nature of nonlethal doses of radiation will reduce effectiveness over extended periods of time
• The effects of electromagnetic pulse (EMP) will degrade unit communications
• The side effects of chemical antidotes will produce short-term reductions in effectiveness
• The psychological effects of mass destruction, fear, and the fatigue of operating in MOPP for extended periods of time will degrade unit effectiveness

g. Population Centers and Boundaries. National boundaries and collateral damage avoidance imposed restrictions to the firing of nuclear weapons in NUREQ-84. Integrated methodologies must be capable of modeling these constraints in the development of nuclear fire plans. The population data base for West Germany reveals forces in contact would see significant increases in population density as the battle moves from east to west across Germany. The application of collateral damage criteria could become the prime consideration in the employment of nuclear weapons. The traditional development of collateral damage criteria is based on the application of terrain-oriented arrays to a discrete population data base in the development of nuclear fire plans. The geographical variations of this population base would require the generation of terrain-oriented arrays for each pulse projected in the assumed scenarios. This could constitute an unacceptable burden (see paragraph 2-2e(2)). A probabilistic treatment of nuclear mission aborts caused by the application of collateral damage criteria (used in TACWAR) would facilitate the modeling of this problem.

h. (U) Weather. Prevailing winds, rainfall, and temperature can enhance or degrade the effectiveness of chemical munitions. For a European scenario, chemical effects would be maximized during the summer months and minimized around February. Effects could be represented consistently in short (30-day) scenarios, but conventional (180-day) scenarios would have to account for variations in effects either using separate inputs or accepting stylized conditions. Table D-2 (extracted from Chemical Research Project, FY 1983-1987) is provided to demonstrate the effects of temperatures, by agent.

Table D-2. Physical Characteristics of Chemical Agents

Chemical agent name and symbol	Type	State at 20° C	Freezing point (C°)	Boiling point (C°)	Odor	Physiological action	Tactical use
Sarin, GB	Nerve	Colorless liquid	-56	158	Fruity	Affects muscle-nerve junctions; cessation of breath followed by death, primarily inhalation	Lethal effects on unmasked personnel, processing of a few minutes
Binary GB, GB-2	Nerve	Colorless liquid	Approximately same as heat GB	Aproximately same as heat GB	Fruity	Same as GB	Same as GB
Soman, GD	Nerve	Colorless liquid	-42	198	Fruity	Same as GB, except also body contract causes casualties	Same as GB except persistency is a few hours and terrain and equipment contamination is a bonus
Thickened soman GD_t	Nerve	[a]	[a]	[a]	Fruity	[a]	Lethal effects on personnel through contact, persistency of days with terrain and equipment contamination
VX	Nerve	Colorless liquid	Below -51	298	Odorless	Same as GB except also body contact causes casualties	Same as thickened GD
VX-2	Nerve	Colorless liquid	Approximately the same as VX	Approximately same as VX	Odorless	Same GB, except also body contact causes casualties	Same as thickened GD
Hydrogen Cyanide, AC	Blood	Colorless liquid	-13.3	25.7	Bitter almonds	Interfer with body tissue use of oxygen, asphyxiation, inhalation	Lethal effects to unmasked personnel, persistency of a few minutes.
Distilled mustard, HD	Blister	Colorless to pale yellow liquid	14.45	217	Garlic	Causes blisters on skin, destroys tissue, primarily contact	Incapacitation of personnel, contact, contamination of terrain and equipment.
Mustard-lewisite HL	Blister	Dark oily liquid	-25.4	Below 190	Garlic	Similar to HD plus may cause systemic poisoning	Same as HD

[a]Not significantly different from GD.

c. Combat Sample Methodology - Corps Level 72-hour Sample (Figure 2-5). This alternative develops an integrated combat sample using a series of high resolution division level simulations to build a Corps Level, 72-hour battle which portrays an expected mix of combat operations. A supporting 72-hour scenario and sets of Corps and division level stylized arrays are required. The scenario (gamer developed) will determine the mission and combat posture of the Corps and its divisions, by day, and determine the timing of the release of nuclear weapons. Three Corps level stylized arrays, matching the postures determined in the gamer developed scenario, are required to support the simulation. Resolution of subordinate units to company level is required for compatibility with NUFAM III. One division in each Corps array would be further defined to develop a set of division level arrays for input to COSAGE to represent the division postures determined by the scenario. The simulation would use COSAGE to develop the combat situation by division by day and produce data forthe development of a composite killer/victim scoreboard and ammunition expenditure. On nuclear or chemical days, NUFAM III would be applied prior to COSAGE gaming, and COSAGE arrays updated by the transfer of data from the Sub Unit Status File (SUSF) used with NUFAM III to the COSAGE unit files. As COSAGE is a 24-hour simulation, it does not reflect the infusion of end of day replacements and end of day changes to unit orders. Consequently, COSAGE orders and unit files must be updated before successive days of combat are simulated. The attrition and expenditure data produced during these simulations must be summed to produce a Corps Level 72-hour combat sample. The use of this combat sample is similar to that outlined in paragraph b, above, except that one mix of unit postures over a 72-hour period is used in place of the four distinct division postures. Accordingly, the scenario of combat activity and equivalent stylized days of combat would reflect variations of one posture as opposed to summing the variations of four.

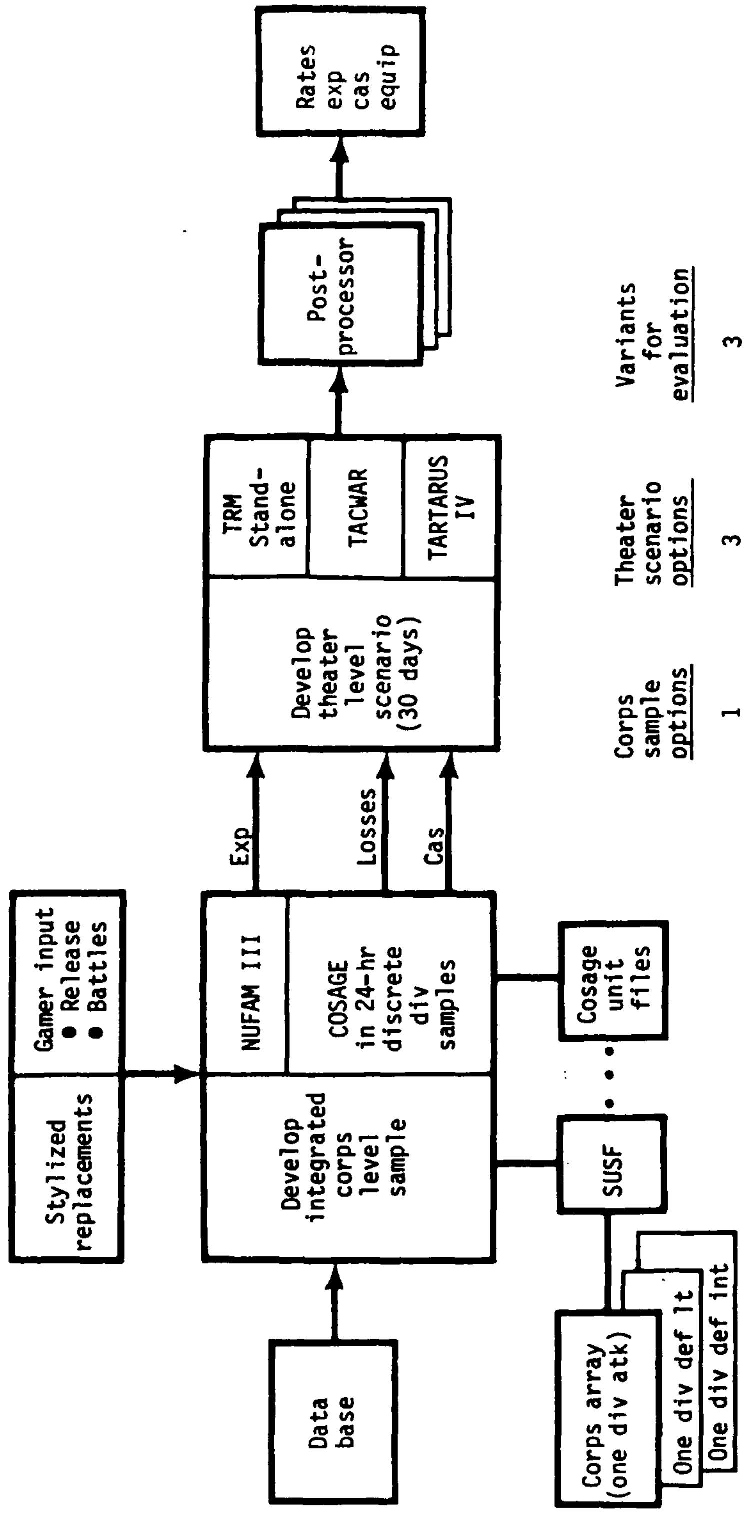


Figure 2-5. Corps Level 72-hour Combat Sample Methodology

E-2. INTEGRATED DEVELOPMENT. Successive applications of NUFAM III or NUFAM II/CHEMCAS and the AMMORATES Models to target arrays would provide integrated combat samples. Methodology development would be based on multiple successive runs of the models against a selected array. Initial runs will identify needs for the development of gamer procedures, supporting utility models, and modification of the component high resolution models. Subsequent runs would develop and test solutions. The high resolution estimate of TMM in Chapter 3 applies to COSAGE. These factors would be increased by a factor of 1.5 for a NUFAM III/AMMORATES combination and a factor of 2 for a NUFAM II/CHEMCAS/AMMORATES combination. These increases are a result of increased operation time required for developmental runs.

APPENDIX F

COSAGE

F-1. GENERAL DESCRIPTION. COSAGE is a two-sided, discrete event, stochastic simulation which deals with land forces. It was designed to deal mainly with forces at the division level and can be manipulated from the platoon-battalion level to brigade-division level. The model develops information on losses of personnel and equipment and ammunition expenditures during a 24-hour period of ground combat at the Blue division level designed to be fed directly to the theater level model preprocessor.

F-2. INPUT

- Strength and weapons.
- Orders for each maneuver unit.
- Weapons data (single shot probability of kill, lethal area).
- Sensor capabilities.
- Terrain data.
- Movement rates.
- Related information.

F-3. OUTPUT

- Killer/victim scoreboard.
- Personnel losses (noncrew).
- Ammunition expenditures.
- Materiel losses (all in computer printout format by side and type).

F-4. MODEL LIMITATIONS

- Plays conventional weapons only.
- Helicopter, mine, and "dirty battlefield" enhancements not fully integrated into model.

- Tactical air support and air defense enhancements not yet developed (see enhancement schedule, below).

- No differentiation made between mounted and dismounted infantry combat (mounted movement followed by dismounted combat requires separate model runs at present).

- One side may move offensively at a time.

- Coordinated unit efforts not yet simulated.

- Model does not yet handle overrun/final protective fire conditions and resultant area versus aimed fire logic.

- Terrain effects are statistically represented by the parameters of the Weibull Distribution. Derivation of the appropriate parameter values is, at present, a time consuming and costly process involving the physical measurement of line of sight/non-line of sight segment lengths between firing positions and target locations on the terrain of interest.

- Model resolution is to Blue platoon level; however, the tactics are representative of the next higher level, i.e., company team and battalion task force operations.

F-5. COSAGE ENHANCEMENT SCHEDULE

Description	Suspense date
Design report for close air support and air defense	Mar 81
Source program and user's manual for close air support and air defense	Sep 81
Design report for intensity	Jun 81
Expanded compiler completion (operational)	Jul 81
In-house development of generalized target acquisition model (fully operational and integrated)	Oct 81
Source program and user's manual for intensity	Dec 81
Design report for submission	Unspecified
Source program and user's manual for suppression	Mar 82
Final report	Mar 82

F-6. FUNCTION IN INTEGRATED METHODOLOGY. COSAGE will produce conventional combat samples for use in the CEM/NUFAM variant. Used in conjunction with NUFAM III, COSAGE will be applied to stylized arrays to develop conventional/chemical or totally integrated combat samples for the other variants. Successive applications of COSAGE will be required for the development of the 72-hour combat sample.

F-7. COSAGE-NUFAM INTERFACE. The key to the development of conventional/chemical or totally integrated combat samples is the interaction between the COSAGE and NUFAM III Models. Three progressive levels of interface, available within present modeling capabilities, are outlined below:

a. Successive Application of Models. NUFAM III is applied to arrays at the beginning of the stylized period. Nuclear and/or chemical casualties and damage are assessed and arrays are updated for the simulation of conventional combat by COSAGE. This interface requires no model modification but requires the manual reformatting of data from NUFAM III to develop COSAGE unit and orders files. COSAGE, a stochastic model, would then be run the required number of replications (estimated to be about 10) and produce killer/victim scoreboards and expenditure data. The averaging of data from the replications is accomplished by a utility program. The composite data produced by this program must then be integrated with the data produced by NUFAM III to produce the integrated combat sample.

b. Application of NUFAM III During the Stylized Period. COSAGE will graphically represent the state of combat activity at predetermined intervals as it proceeds through the stylized period. An analysis of the tactical situation can be used by gamers to determine the opportune time to apply NUFAM III. This time would be based on an average tactical situation after considering all replications produced by COSAGE. COSAGE would then be rerun for that specified time, NUFAM III would be applied to develop nuclear and/or chemical data, and COSAGE would be restarted with new input to complete the stylized period of combat. This procedure requires an application of NUFAM III for each replication and requires a utility program to develop unit data from the COSAGE files (unit identity, location, current strength, equipment on hand) to develop arrays for NUFAM III. This data is available in memory but is not retrieved for current outputs. The update of COSAGE files after the application of NUFAM III as outlined in a, above, would then be followed for each replication.

c. Software Assisted Interface. The previous interfaces require the manual translation of input/output files and integration of attrition and expenditure data. Because of the stochastic nature of COSAGE, the operational burden is particularily severe if NUFAM is not used before the initiation of the conventional warfare portion of the simulation.

This burden can be appreciably diminished by the development of a data reformater to translate between COSAGE and NUFAM formats and a utility program to integrate the results of the integrated and conventional portions of the simulation. An example of a successfully demonstrated data reformater is provided in Appendix M (data transferral).

F-8. RESOURCE REQUIREMENTS. Estimates of the level of developmental effort in TMM to incorporate COSAGE as a component of an integrated methodology are listed below by methodological alternative:

a. Division Level 24-hour Combat Sample Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	4.0 TMM
(3) Operational testing	5.0 TMM
Total	9.5 TMM

b. Corps Level 72-hour Combat Sample Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	7.5 TMM
(3) Operational testing	9.5 TMM
Total	17.5 TMM

c. Continuous Combat Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	4.5 TMM
(3) Operational testing	9.0 TMM
Total	14.0 TMM

d. CEM/NUFAM Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	0.5 TMM
(3) Operational testing	5.0 TMM
Total	6.0 TMM

APPENDIX G

NUFAM II/III

G-1. GENERAL DESCRIPTION. NUFAM II is a two-sided, corps level, free-running stochastic simulation. It includes dynamic interactions operating on a static array to represent the fire planning and delivery of nuclear indirect fire and bombs to estimate their effects on units, their equipment and personnel, and the adjacent civilian population. Simulated time is treated on an event-store basis, using the GASP IV language. The nuclear exchange is simulated by automating, based on input criteria, the selection of nuclear targets and the allocation of firing assets against these targets while minimizing civilian casualties.

G-2. INPUT

- Several types of input data are required. These define commander's firing guidance, fire planning, weapon characteristics, assessment parameters, GASP IV preplanned information, civilian collateral damage criteria, and MOE unit definitions.
- Inputs include: acquired targets list, firing units, weapon yields/rounds available, and battlefield unit information.

G-3. OUTPUT

- Time sequenced list of all events.
- Fire event results.
- End of period status of all units.
- Civilian population at predictive risk and civilian casualties (assessed).
- Histograms and CALCOMP plots (optional).

G-4. MODEL LIMITATIONS

- No cumulative radiation from multiple burst, or distribution of delayed casualties in time.
- Assesses only two casualty categories.
- Assesses damage to only one item of equipment/unit.

G-5. MODEL IMPROVEMENTS (NUFAM III). NUFAM III will expand the capabilities found in NUFAM II by integrating chemical and nuclear fire planning and assessment. Other added improvements include effects assessment of migratory nuclear and chemical clouds, incorporation of target acquisition (formerly done off-line), and the capability to assess three levels of personnel casualties and damage to more than one item of equipment per unit.

G-6. FUNCTION IN INTEGRATED METHODOLOGY. NUFAM III will be used in conjunction with COSAGE to develop integrated combat samples for the division and corps level combat sample variants. NUFAM III will be used independently in the CEM/NUFAM and continuous combat variants upon determination of N-day to develop data resulting from the simulation of a nuclear pulse.

G-7. RESOURCE REQUIREMENTS. Estimates of the level of development effort to incorporate NUFAM III as a component of an integrated methodology are listed below by methodological alternative:

a. Division Level 24-hour Combat Sample Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	3.0 TMM
(3) Operational testing	4.0 TMM
Total	7.5 TMM

b. Corps Level 72-hour Combat Sample Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	5.0 TMM
(3) Operational testing	8.0 TMM
Total	13.5 TMM

c. Continuous Combat Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	3.5 TMM
(3) Operational testing	8.0 TMM
Total	12.0 TMM

d. CEM/NUFAM Alternative

(1) Model modification/design	0.5 TMM
(2) Interfaces	2.8 TMM
(3) Operational testing	4.5 TMM
Total	7.8 TMM

APPENDIX H

THEATER RATES MODEL (TRM)

H-1. GENERAL DESCRIPTION. The TRM is a two-sided, deterministic model. It simulates theater level conflict on a daily basis to determine ammunition expenditures of all Army weapons engaged in conflict. It uses stylized losses (generated by high resolution simulations) and an input stylized Blue force to create theater-wide equivalent stylized days of combat for each Blue weapons system. TRM may be set to run with an externally derived scenario, or it may be set to generate its own scenario by using opposing force potentials. (The first mode was the one used in recent ammunition requirements analyses.) In recent ammunition requirements studies, the TRM has been operated with a scenario externally provided by the Concepts Evaluation Model (CEM).

H-2. INPUT

- Stylized Red and Blue forces.
- Stylized personnel casualties and weapon system losses from all forms of combat. (TRM can accept two sets of K/V scoreboards. This capability has traditionally been used in a good weather/bad weather mode.)
- Red and Blue force deployment schedule.
- Scenario of combat activity (percentage of Red force opposing Blue when Blue is in each posture, by day).
- Maintenance/repair factors.
- Infantry and artillery by-posture combat effectiveness (as a function of strength).
- Min and max Red armies on line.
- TACAIR potential kills of tanks, APCs, and troops.

H-3. OUTPUT

- The model generates "equivalent stylized days (ESD) of combat" for input to the Rates Generator Model (RGM) to produce day-to-day ammunition expenditures. (An ESD is a multiplicative factor, defined as the proportion of stylized expenditures that is estimated to occur in the actual force slices. The ESD are accumulated across all of the Red army slices deployed in line on the current simulation day.)

- Daily loss rates of modeled weapons system.

H-4. MODEL LIMITATIONS

- The course of the war is predetermined. Combat activity is dictated by an externally developed scenario (i.e., density of force postures).
- Blue and Red units are aggregated into "equivalent stylized forces."
- Models up to 30 Blue and 10 Red weapons types, including tactical air support.
- Blue and Red deployments into the theater are aggregated into personnel and equipment pools from which the model attempts to create stylized units.

H-5. STANDALONE MODE. The TRM(SA) is capable of generating its own scenario (profile of combat activity). The model differs from the TRM used historically in conventional ammunition rates methodology in that the front activity of the theater is determined by the force ratio as determined by cumulative firepower potentials of the opposing forces and compared to four threshold values within the TRM. The methodology for determination for percentage of the front in specific activity is illustrated in Figure H-1. Additional input is required for TRM(SA) in the form of FPP data. The output is the same as that produced by TRM, but is limited in the number of combat samples (two) that can be used on each day of combat to represent combat activity across the theater.

H-6. FUNCTION IN THE INTEGRATED METHODOLOGY. The TRM(SA) will be operated in conjunction with two sets of combat samples (conventional/chemical and total integrated). Successive runs will be used to develop the profile of combat activity and determine the timing of nuclear pulses. After a determination is made as to which will be represented by the totally integrated combat samples, a final run will be made using TRM. TRM was selected for the computation of ESDs to provide the capability of adjusting (with gamer judgment) the final scenario to portray all four combat samples in each day of combat. The daily loss rates for selected weapons systems produced by TRM will provide data for the computation of WARF rates in non-CEM methodological alternatives.

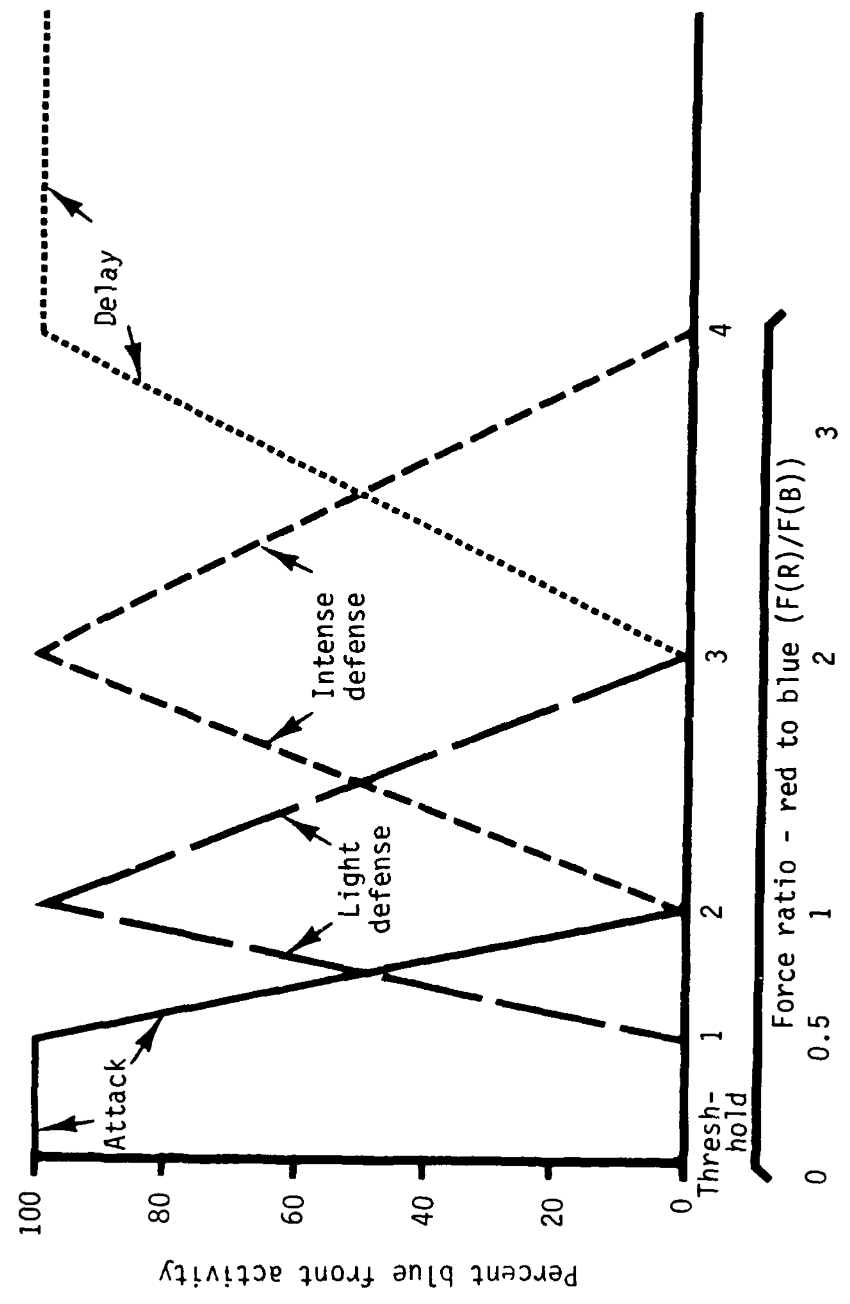


Figure H-1. TRM(SA) Determination of Blue Front Activity

H-7. RESOURCE REQUIREMENTS. Estimates of the level of developmental effort in TMM to incorporate TRM as a component of an integrated methodology are listed below by methodological alternative:

a. Division Level 24-hour Combat Sample Alternative

(1)	Model modification/design	0.5 TMM
(2)	Interfaces	1.5 TMM
(3)	Operational testing	3.0 TMM
	Total	5.0 TMM

b. Corps Level 72-hour Combat Sample Alternative

(1)	Model modification/design	3.0 TMM
(2)	Interfaces	3.0 TMM
(3)	Operational testing	5.0 TMM
	Total	11.0 TMM

APPENDIX I

POSTPROCESSORS

I-1. GENERAL. The transformation of data produced by high and low resolution simulations into the rates/expenditure data defined in Figure 2-1 is accomplished by ammunition and materiel postprocessors. The use of these postprocessors and utility models that may replace or augment them is discussed below.

I-2. AMMUNITION POSTPROCESSORS. Conventional and chemical ammunition rates are produced in all the methodological alternatives except continuous combat by the successive application of the Ammunition Postprocessor (APP) (when the theater model is CEM) or the Theater Rates Model and the Rates Generator Model (RGM). The APP and TRM develop equivalent stylized days of combat (ESD) which are used in the RGM to develop rates. The operation of the TRM is discussed in Appendix H. The APP differs from TRM in that it is nôt a simulation and does not refight the war to develop ESD. Instead of using opposing force levels in conjunction with the high resolution stylized losses in a combat simulation, it compares the CEM generated losses and the high resolution stylized losses to create ESD for each combat posture. The RGM uses the ESD output from APP or TRM, stylized expenditures by posture, weapons deployment data and deployment and replacement factors to calculate the rounds required by each weapon system for each specified time period of the war. In addition to rates, the RGM will also produce ammunition requirements and tonnage by time period; however, these data are based on the total number of weapons deployed in theater and are not directly usable for computing nuclear and chemical expenditures. For the combat sample alternatives, the ESD from TRM or APP and stylized expenditures from high resolution simulations must be used. In the CEM/NUFAM III, a manual accounting or summing developed in utility programs is required.

I-3. UTILITY MODELS. The ammunition postprocessors described above are not compatible with the Continuous Combat Alternative. The number of combat postures included in the reference set of division combat samples exceeds the capability (four postures) of the postprocessors. A utility model is required to sum the daily expenditures, to compute the average theater TOE authorization of weapons for the period, and to develop ammunition rates. It would be convenient to use the same program to sum combat attrition data for the development of WARF. In the CEM/NUFAM III alternative, ammunition rates/expenditures are produced in successive runs and require consolidation to depict true rates/expenditures for the total time period. This could best be accomplished by a utility program.

I-4. WARF POSTPROCESSORS. WARFs are developed by exercising the methodology in an unconstrained equipment mode. WARFs for major item direct fire losses are produced by the direct extraction of attrition data for input into the WARF control file. These data are then integrated with noncombat losses in the Equipment Loss Consolidator (ELCON) to produce rates. WARF for other items are produced from attrition developed in the WARF Intermediate Materiel Processor (WIMP) which uses the results of artillery and tactical air missions to recompute losses of equipment by vulnerability category. These losses are compared to item density profiles to extract losses for specific items and consolidated with noncombat losses in ELCON to produce rates. Figures I-1 through I-4 show the WARF methodology flowcharts for the four methodological alternatives.

I-5. QUALITY OF WARF. Two significant factors must be considered when evaluating the quality of WARF data.

a. The WARF flowcharts depict input to the ELCON from the SYMWAR Historical File. Data obtained from that file will not provide an accurate portrayal of losses expected in an integrated environment. Other sources for estimates of equipment lost behind the division area will be required to supplement these data.

b. WARF for major items currently developed with direct fire attrition data from CEM is the acceptable standard. The only methodological alternative which approximates that standard is the CEM/NUFAM III alternative.

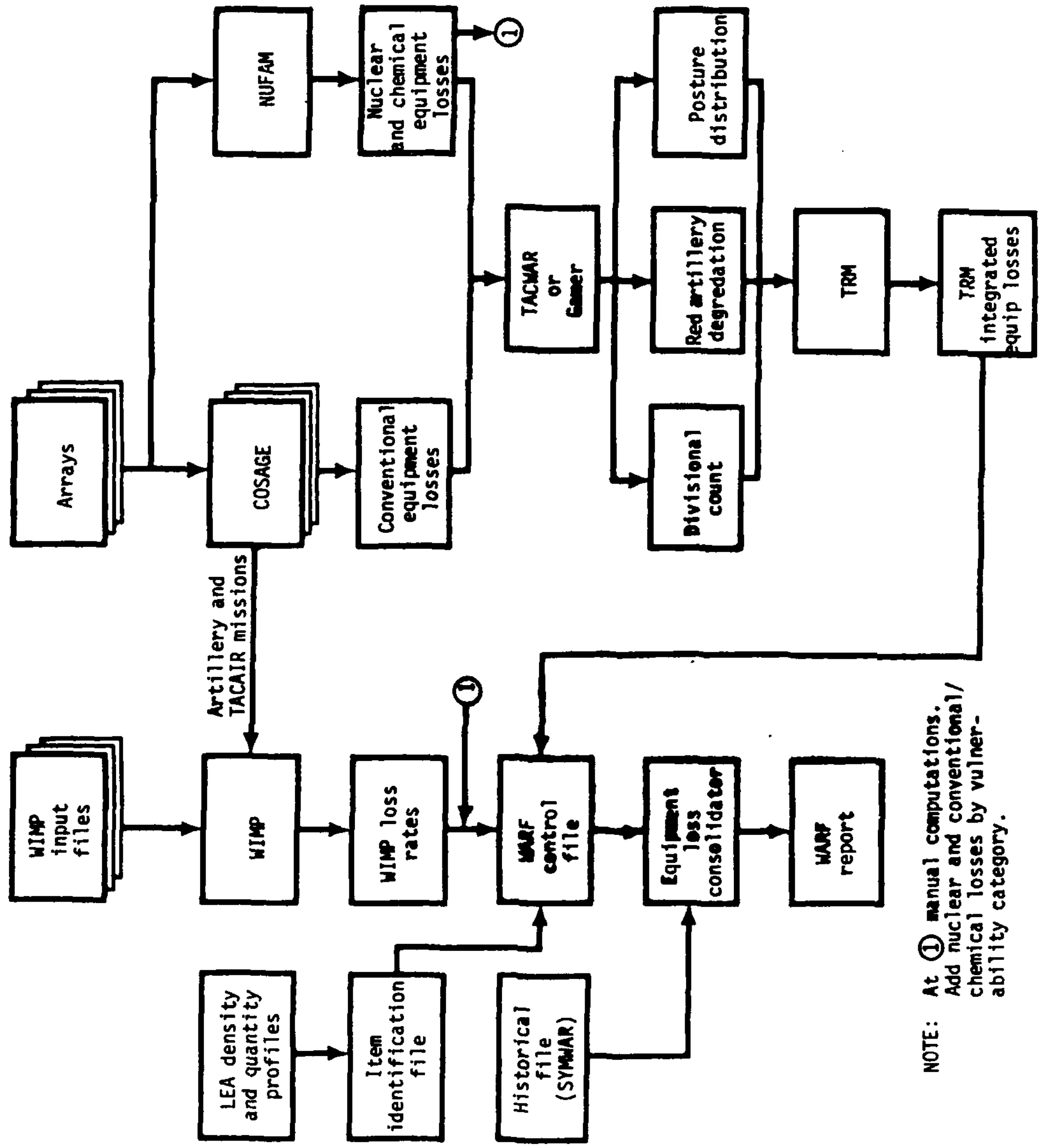


Figure I-1. WARF Flowchart - Division Combat Sample

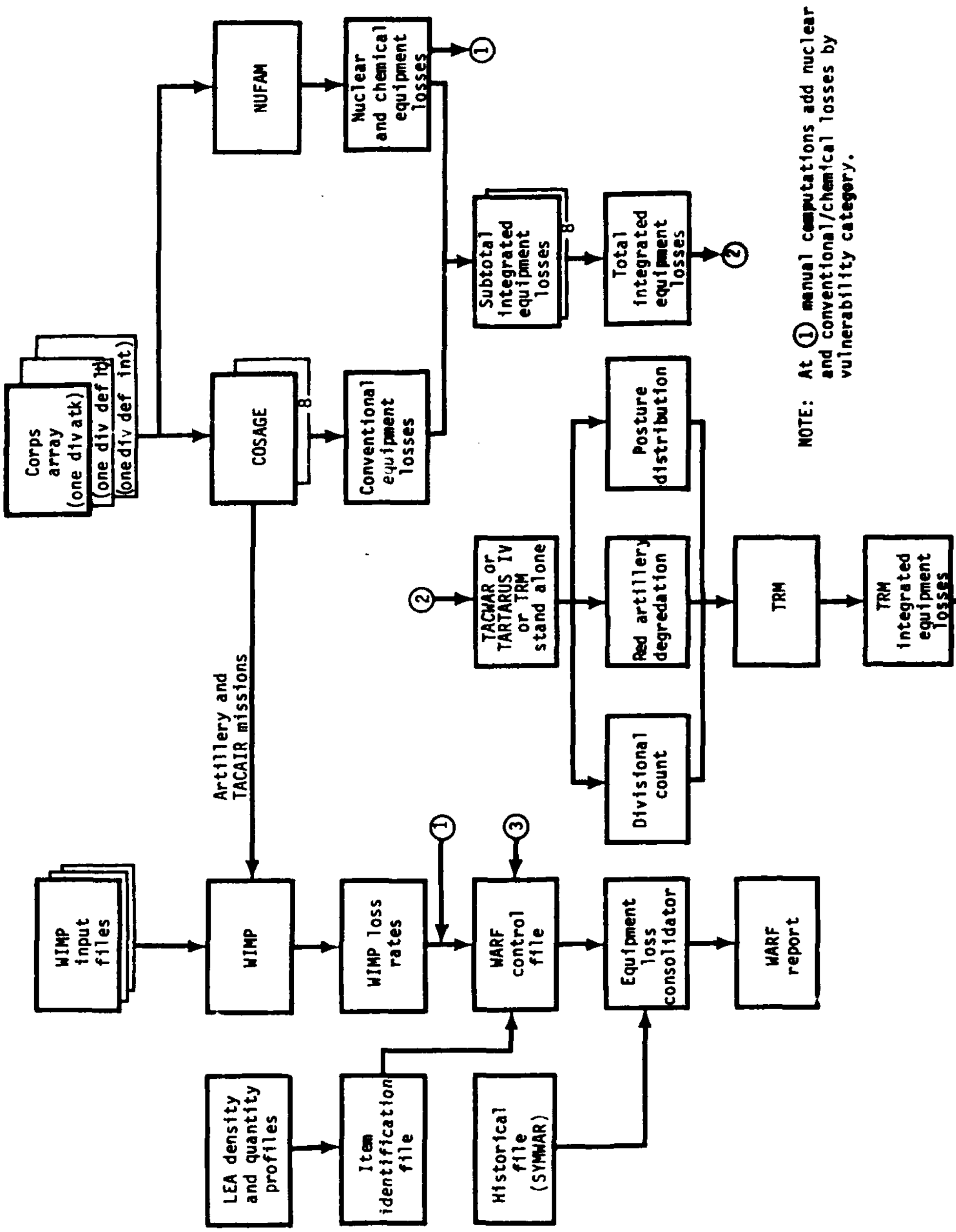


Figure I-2. WARF Flowchart - Corps Sample

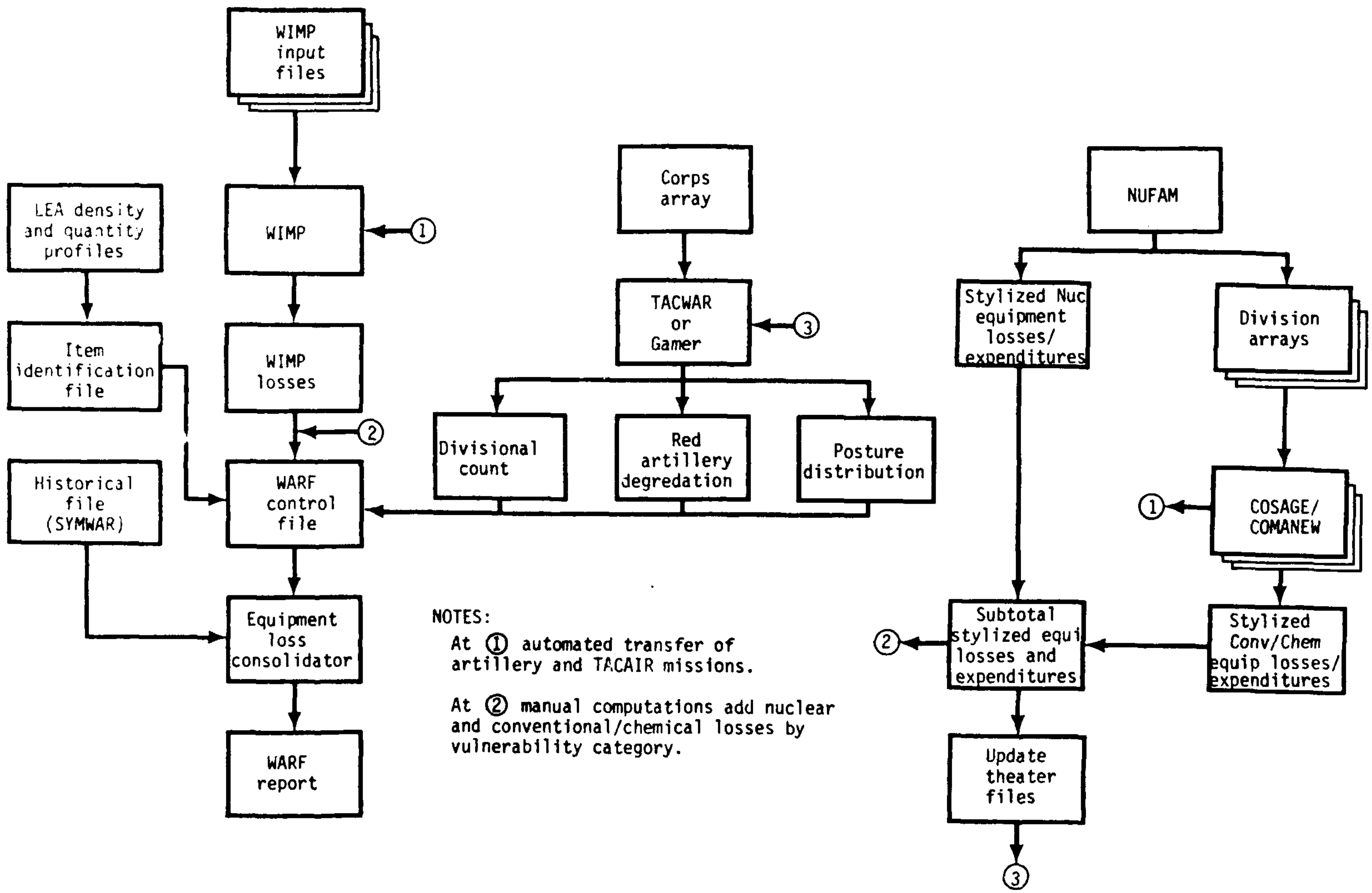
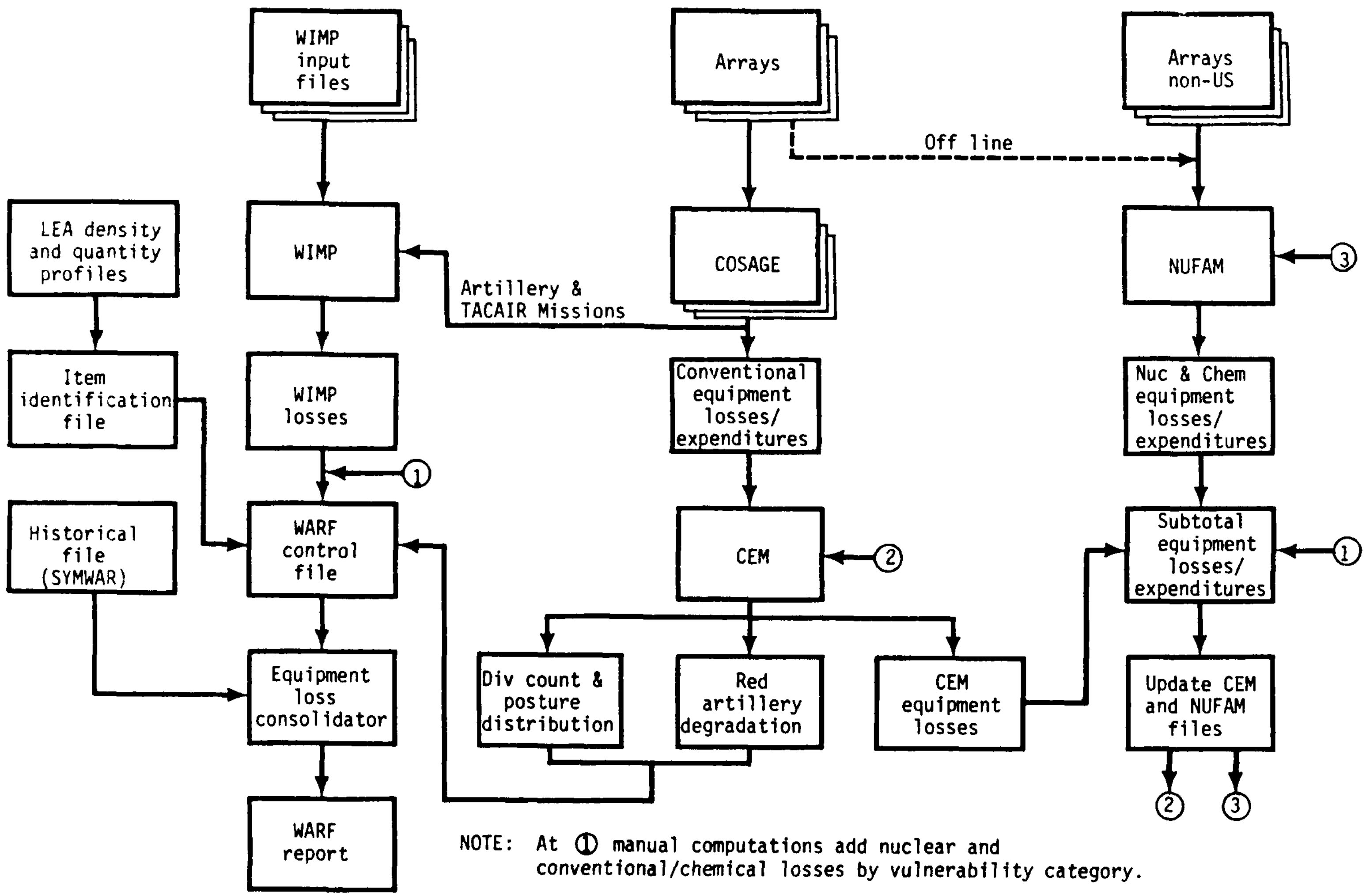


Figure I-3. WARF Flowchart - Continuous Combat



NOTE: At ① manual computations add nuclear and conventional/chemical losses by vulnerability category.

Figure I-4. WARF Flowchart - CEM/NUFAM III

APPENDIX J

CONCEPTS EVALUATION MODEL (CEM)

J-1. GENERAL DESCRIPTION. CEM is a two-sided, deterministic model involving land and air forces. It is designed to consider groupings as small as a brigade on the Blue side and a division on the Red side, and can aggregate up to the level of a theater army (and air force). Simulated time is treated on a time-step (division cycle) basis (normally every 12 hours). The model simulates the course of a theater level, nonnuclear war in terms of FEBA location, condition of opposing forces, and expenditure of resources.

J-2. INPUT

- Terrain map.
- Military objectives.
- Troop lists.
- TOEs.
- Weapon firepower indices.
- Resupply and replacement rates.

J-3. OUTPUT

- Computer printout stating (periodic) FEBA location, state of opposing forces, and resources expended.

J-4. MODEL LIMITATIONS

- Blue brigade structure cannot be changed during a war.
- Reserve units (if any) consist of exactly one of the next lower echelon unit.
- Logistic operations highly aggregated.
- In any one run, the model requires a continuous FEBA; no overrun, penetration, or encirclement conditions; and no dynamic, interactive changes of input values.

- Four terrain types (with the nonbarrier adverse "C" type terrain, such as soft sand and high mountainous terrains, having the same effects on battle outcome).

- Weapons types are currently limited, per side, to 12 tanks, 12 light armored vehicles, 5 helicopters, 12 antitank or mortar systems, and 8 artillery systems.

- The results of tactical air support employment and air defense attrition of tactical air are highly aggregated in the current version.

J-5. FUNCTION IN INTEGRATED METHODOLOGY. Short duration CEM runs (10-15 days) will be used to determine conditions for a nuclear pulse. Subsequent runs with the same input decks will develop conventional requirements data through N-day. An off-line integrated analysis using NUFAM III will then provide integrated data and attrition information for use in developing CEM decks for continuing the simulation. Attrition data for selected major items produced by CEM will be integrated with nuclear combat losses produced by NUFAM III for the development of WARF rates.

J-6. RESOURCE REQUIREMENTS. Estimates of the level of developmental effort in TMM to incorporate CEM as a component of an integrated methodology are listed below:

<u>Division Level 24-hour Combat Sample Alternative</u>

• Model modification/design	5.0 TMM
• Interfaces	4.5 TMM
• Operational testing	7.5 TMM
Total	17.0 TMM

APPENDIX K

ALTERNATIVES TO THEATER SIMULATIONS AND CALIBRATION

K-1. GENERAL. The development of non-CEM methodological alternatives requires the integration of suitable substitute low resolution simulations. The simulations selected by the study team were the Tactical Warfare (TACWAR), TARTARUS IV, and Theater Rates Model operated in the standalone mode (TRM(SA)). These simulations were selected on the basis of anticipated availability and their potential for simulating integrated warfare by virtue of model logic, the use of integrated combat samples, and/or their capability for gamer interface. TRM is discussed in Appendix H. The characteristics of TACWAR and TARTARUS are discussed in following paragraphs. In both models, the factors that determine attrition and the very process itself are decidedly different from those found in most high resolution models. So that aggregated results of these models are consistent with the results of the high resolution model (COSAGE) used in the methodology alternatives, calibration to COSAGE attrition data as presented in killer/victim scoreboards is required. As the study team found no evidence that TACWAR or TARTARUS had ever been calibrated to the results of high resolution simulations, programers and operators most familiar with these models were presented with the problem and briefed as to the purpose and importance of calibration in the context of its use in the methodological alternatives. Their assistance was then solicited to participate in outlining procedures to best achieve this end. Proposed procedures to accomplish this calibration are provided in subparagraphs K-2g and h (TACWAR) and K-3g (TARTARUS). The technical risks and required follow-on efforts pertinent to the calibration of TACWAR and TARTARUS are presented in the body of this report in Chapter 3, paragraph 3-4a and Chapter 4, paragraph 4-3b, respectively.

K-2. TACWAR

a. TACWAR evolved from a series of models beginning with A Tactical, Logistical, and Air Simulation (ATLAS); the Ground-Air Campaign Model (GACAM); and the Institute for Defense Analyses Ground-Air Models I and II (IDAGAM I and II).

b. The TACWAR Model is a completely automated combat simulation that can be used to assess the interactions of combat forces employing conventional, nuclear, and chemical weapons in a theater-wide campaign. The model can simulate the delivery of conventional, nuclear, and chemical munitions by both air and ground means anywhere in the theater. The model can be used to simulate conventional warfare, or conventional warfare plus either chemical or nuclear warfare, or conventional warfare plus both chemical and nuclear warfare. The program incorporates facilities that enable the user to model a specific geographical structure for the theater. The theater structure includes sectors, battle areas, regions, and communications zones (COMMZ). The opposing forces located within this structure are on opposite sides of a line called the FEBA. This structure is then used as the foundation for seven simulations: target acquisition, air combat, nuclear combat, chemical combat, ground combat, theater control, and supplies transportation. The model provides for the opposing sides to be represented in a symmetrical manner by combat assets whose number and capability are input to the model by the user. These assets are summarized as follows:

(1) Ground Combat Resources

- Division size units
- Company size, divisional subunits
- People, weapons, and supplies for each unit
- Nuclear and chemical systems
- Surveillance sensors

(2) Air Resources

- Tactical aircraft
- Reconnaissance aircraft
- Aircraft shelters at actual or notional air bases
- Surface-to-air missiles (SAMs) and antiaircraft artillery (AAA) as point or area defenses
- Supplies at air bases

(3) Other Resources

- Nuclear warheads
- Chemical munitions
- Nondivisional missiles and rockets
- Supplies at nodes in the supply network

c. In addition to the above resources, the size and location of the civilian population in the theater are considered in the model as a constraint on the employment of nonconventional weapons. Although divisional subunits (such as companies, batteries, headquarters, and others) are represented in the model, their representation is for purposes of target acquisition and damage assessment. These subunits are not uniquely identified or maneuvered. The basic resolution of the model is at the division level where unit identities, strengths, and locations are maintained during the course of the game play.

d. The duration of the wargame is set by the user and is measured in 12-hour cycles. Output reports are generated by the model at the end of each cycle. The theater control submodel operates on this basic 12-hour cycle time clock to accomplish such tasks as resupplying units, adding arriving divisional units, moving the FEBA, and assigning aircraft to missions. However, there are two other time clocks in the model. The supply submodel utilizes a user-specified cycle which is a multiple of the basic game cycle. For example, the movement of supplies between supply nodes might be accomplished every sixth or eighth game cycle. The target acquisition, nuclear, and chemical submodels, on the other hand, operate on a user-specified cycle which is a subcycle of the basic game cycle.

e. The conventional fire exchange is a portion of the ground submodel and handles assessments on divisional size units; however, to furnish information needed by the target acquisition nuclear and chemical submodels, data on divisional subunits and zones within divisional areas are also provided. In order to simulate the theater ground campaign, in addition to the theater structure, TACWAR must have information not only on the locations, numbers, and types of divisions but also on the personnel, weapons, and supplies in each division. The cycle at which divisions not in the theater initially will arrive must also be known. These data provide the ground submodel with the principal information on the deployment of the ground resources from which the force ratio in each sector may be computed, casualties assessed, and the FEBA movement calculated each cycle. Additional information from other submodels is also required, of course, such as type of terrain from the theater submodel, the effect of close air support from the air submodel, the casualties from nonconventional weapons (if played).

f. Elements of the attrition process can be illustrated in a summarized version of the TACWAR basic structure by the following four steps:

(1) Step 1. The allocated potential of a particular Blue weapon or Blue air sortie against a particular Red weapon is determined based on Blue's allocation of fire against all Red weapons, the number of Red weapons available as targets, and the individual potential of Blue's weapon or air sortie against the Red weapon.

(2) Step 2. The allocated potential values are translated into individual weapon values for each Blue weapon or air sortie to cause casualties and destroy weapons within the Red force by considering the weapon value destroyed when a particular Red weapon is killed by a particular Blue weapon or air sortie. This concept is referred to as the antipotential potential method for computing weapon value.

(3) Step 3. Adding the values calculated in Step 2 over all Blue weapons in the immediate combat area produces the total Blue weapon value measured in terms of Red weapon value destroyed.

(4) Step 4. Finally, the ratios of corresponding Red and Blue weapon values (considering ground weapons and close air support sorties) are used with empirical data such as force ratio relationships to produce Red and Blue personnel casualties and weapons destroyed.

g. In order to calibrate the output of TACWAR to the results of high resolution modeling, the following groups of variables can be used:

(1) The parameters for modifying unit effectiveness based on weapon attrition;

(2) The parameters for modifying unit effectiveness based on personnel casualties.

(3) Scaling factors for the computation of personnel casualties as a function of force ratio.

h. An example of a type procedure is as follows:

(1) The high resolution K/V results are used to estimate an initial set of constant values for the weapons system parameters. (The current version of TACWAR allows a variable number of weapons classes, and can be structured to correspond exactly with the weapons played in the high resolution model). The arrays used to generate killer/victim scoreboards are used to develop forces to be gamed in four sectors in TACWAR. The forces are represented by the standard combat postures of attack, delay, defense intense, and defense light, and the forces are the sole occupants of each sector. TACWAR is repeatedly executed varying the system parameters until the ratio of losses in each sector closely approximates the corresponding K/V scoreboard. This is essentially a trial and error process iterated until a reasonable relationship is determined. Thus, a set of system parameters is developed.

(2) The output at this point is in the same proportion (ratio) to K/V scoreboard results and must be scaled up or down to adjust the overall structure such that the number of losses from the TACWAR simulations approximates those losses resulting from the high resolution model. Further efforts will then be required to ascertain the extent that TACWAR will produce attrition data corresponding to the results of the high resolution model with variations in weapon mixes.

K-3. TARTARUS. The TARTARUS Model is a computer-assisted, theater-level, wargaming model with combat aggregated at the brigade or division level.

a. Player Actions Players using the model decide where, when, and how combat units are to be committed. They also allocate artillery to combat units and select targets for engagement by close air support. Players analyze TARTARUS outputs reflecting game conditions at the end of each 12-hour game interval. Changes to or new orders are developed for input to the model for the succeeding game interval.

b. Model Performance. The model assesses the actions and interactions resulting when units respond to the mission orders assigned by players. The model determines which target units will be fired upon by each firing unit, how much fire by category will be delivered on each of the opposing targets, and assesses personnel and materiel losses inflicted by the exchange of fire. The model also determines how fast and in what direction each unit moves and to what extent the unit's weapons are suppressed by incoming fire. These calculations are made during each iteration interval. Iteration intervals are normally 6 minutes long.

c. Fire Exchange Assessment. TARTARUS simulates the exchange of fire between opposing units and assesses the loss of personnel and materiel caused by the exchange.

(1) Each weapon is assigned a firepower potential (FPP) value and has an effective range associated with it. In simplified terms, the FPP of a weapon is the product of the number of rounds the weapon is expected to fire per hour and a lethal area per round for antipersonnel weapons, or the product of the expected number of rounds fired per hour and the single shot probability of kill for antimateriel weapons.

(2) Weapons are divided into 10 ground weapon classes. Each unit in TARTARUS has an FPP developed from one or more weapon classes; the FPP of a unit's weapon class is the sum of the FPP of the weapons that the unit has in that class. Each weapon class of each unit also possesses a range profile that establishes the percentage of the weapons in that class to fire at a given range.

(3) The 10 ground weapons classes are further divided into 3 fire classes. Each fire class contains weapon classes that deliver suppressive fires with similar effects on the targets unit's ability to return fires and to move. When determining how much FPP the firing unit can deliver from any weapon class during one iteration interval, the model considers the suppression by incoming fire from all opposing units, as well as the percentage of the weapons in that class that cannot be fired on targets, when the firing unit is moving.

(4) The foregoing considerations and computations enable TARTARUS to determine the amount of fire, by fire class (small arms, tank, anti-tank, artillery, mortar, etc.) received by any unit within the 6-minute iteration interval. The total volume of fire, by fire class, received by a unit is used to compute the suppression effect on its FPP and movement rate.

d. Movement Assessment. The TARTARUS Model computes a movement rate for each unit at each 6-minute interval. Units with offensive missions move forward toward the objectives, while units with defensive missions hold their positions and move to the rear only when receiving sufficient fire to force retrograde movement. The movement rate is computed for a unit as a function of the volume of fire by fire class received from all opposing units, the unit's specific capability (FPP), the unit's unopposed movement rate in the terrain being traversed, and the unit's (defensive only) commitment expressed as unit hardness (protective posture).

e. Attrition Assessment. The TARTARUS Model determines how a firing unit distributes its FPP in each weapon class among target units. The model also determines the distribution of incoming FPP of a weapon class over the weapon classes of each target unit. Thus, the model calculates how much fire of each class is delivered by all opposing units against each weapon class of the target unit. TARTARUS then calculates the losses suffered by each weapon class of each unit by taking into consideration the effectiveness (capability to kill) of a weapon class versus a target weapon class expressed as a modified effective lethal area. The firing weapon effective lethal area is modified by an attrition factor based on unit mission and the FPP of the weapon class divided by the target unit width. Attrition of FPP (weapons) is computed each 6 minutes.

f. Major TARTARUS Components and their Functions. TARTARUS consists of the following three major components:

(1) The Input Processor (IP). The IP initializes data for input to the differential model and provides a printout of periodic information for player decisionmaking as the game proceeds. Weapon status is reported in terms of FPP values for each weapon class.

(2) The Differential Model (DM). The DM provides reports to players with end-of period unit status, detailed strength and losses and other data. Detailed materiel strength and losses remain expressed in terms of FPP in each of the 10 weapon classes. The DM also provides an output file for use by the output processor.

(3) The Output Processor (OP). The OP produces the end of period cumulative unit status file and the detailed personnel and weapon losses by type weapon and by weapon class for each game period.

a. Calibration

(1) Current Calibration. Movement and attrition parameters are usually adjusted in the TARTARUS Model for each new study project. Calibration of these parameters is explained in Chapter 5, Parameter Adjustment, TARTARUS V N/COCO War Gamer's Manual, CAA-D-78-6, August 1978. Calibration is accomplished by repetitive exercise of the model using sample inputs with each iteration. Experience in calibrating the TARTARUS Model is a prerequisite to attaining reasonable results with minimum time and effort. The reasonable results attained in this case are normally based on historical precedence; or the best judgment of the analyst performing the calibration.

(2) Calibration of Attrition to K/V Scoreboards

(a) TARTARUS attrition can be calibrated to K/V scoreboards by the following procedures:

1. Step 1. Duplicate the opposing forces and weapon mixes in TARTARUS as used in the high resolution model simulation that produced the K/V scoreboards oriented to each combat posture (TARTARUS mission).

2. Step 2. Introduce player orders to reproduce the mission represented for the period covered by each high resolution model generated K/V scoreboard, e.g., Red attack vs Blue defense for a period of 24 hours.

3. Step 3. Aggregate all K/V scoreboard losses by TARTARUS weapon class.

4. Step 4. Adjust the parameter(s) impacting on attrition through successive TARTARUS interations in each combat posture until TARTARUS losses approximate losses in each applicable K/V scoreboard.

5. Step 5. Separate losses within each weapon class to approximate each weapon system loss as found in given K/V scoreboards for each TARTARUS mission.

6. Step 6. Repeat the preceding five steps to adjust attrition factors for non-US-NATO vs non-USSR WP and other combinations of opposing forces represented in K/V scoreboards for each combat posture, as necessary.

... 11

(5) ... are six TARTARUS inputs that impact on conventional ... by modifying a unit's ability to deliver fires, ... in FPP on a target. These are: weapon class vs weapon class ..., attrition factors, fire suppression factors, firer degradation ... to movement factors, firing rate modifers, and maximum range firing .... Of these inputs, attrition factors and firing rate modifiers ... any calibration requirements encountered. A single set of ... factors is input to establish rates at which each of the 10 ... classes will lose FPP and personnel in both Red and Blue units ... each of the seven missions. Adjustment of attrition factors ... simultaneously scale both Red and Blue losses in all 10 weapon ... up or down, as required. Firing rate modifiers are used to ... firing rates used in the development of FPP by Blue and Red ... weapon class, and TARTARUS mission. Used in the calibration process ... firing rate modifiers can be adjusted by Red or Blue side and by ... class to converge on the losses shown in both the Red killer/Blue ... and Blue killer/Red victim scoreboards associated with each com... Once TARTARUS attrition is calibrated to all weapon class ... scoreboards, firing rate modifiers would be held constant ... simulation of theater-wide combat.

... TARTARUS reports personnel, weapon class and individual ... system losses via the output processor. The output processor ... weapon class losses into individual weapon systems losses ... on weapon population distributions within the weapon class for .... In calibrating the TARTARUS to K/V scoreboards, instead of using distribution of available weapon systems within a class, ... distribution of weapon systems losses within classes as found in the ... can be used. Accomplishing this change in logic will re... modifications to the output processor.

... CALIBRATION SUMMARY. The proposed system for calibrating TACWAR ... TARTARUS to K/V scoreboards is based on the adjustment of parame.... The difference, however, is that the current methodologies are ... on historical data, whereas the methodologies proposed adjust ... parameters within the model to obtain results approximating the ... by high resolution models.

APPENDIX L

OTHER MODELS/WAR GAMES CONSIDERED

L-1. INTRODUCTION. During the course of this study, several simulations and war games, in addition to those selected as components of the alternatives evaluated in Chapter 3, were examined as potential candidates. Those given serious consideration, but subsequently rejected as candidate models, are listed in paragraph L-2 with the reasons for rejection.

L-2. MODELS AND WARGAMES CONSIDERED AND REJECTED

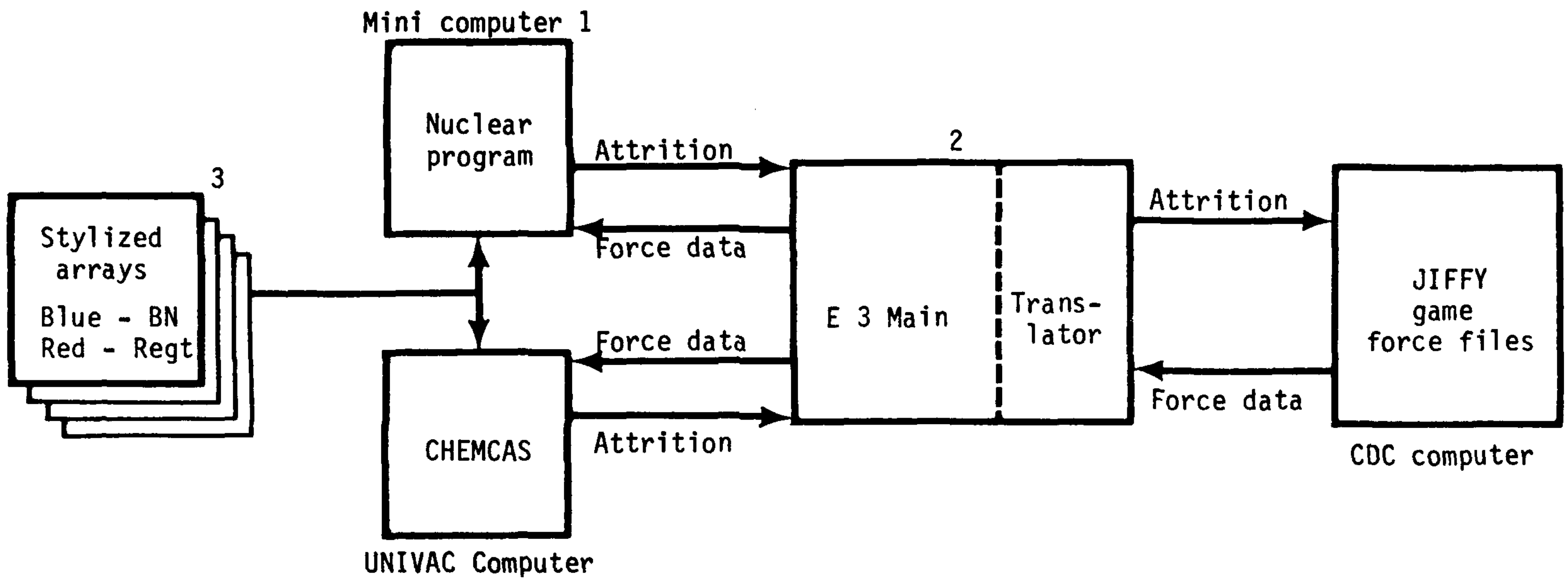
Model/wargame	Reason(s) rejected
AMMORATES Models	Considered as a candidate to be interfaced with CHEMCAS or NUFAM III for the development of integrated combat samples. Not selected because they are being replaced by COSAGE. However, the AMMORATES Models have been retained in a backup capacity.
SCORES III	Considered as a candidate for the development of division and corps level integrated combat samples. Rejected as too time consuming: one 6-hour period of simulated war for a corps requires over a week of gaming and analysis. Also rejected on the basis of resources required; two mainframe and several microcomputers operated by a large team of gamers.
ICOR	Considered as a candidate for the development of corps level combat samples. Rejected as too time consuming; several months of set-up time plus 1 week of gaming for 24 hours of battle time.
INWARS	Considered as a theater level model to replace CEM. Rejected due to the significant software development remaining to get the model fully operational.

APPENDIX M

DATA TRANSFERS

M-1. GENERAL. Until the development of individual models capable of simulating the synergistic effects of combinations of conventional, chemical, and nuclear weapons, these effects must be developed by interfacing or aggregating the results of separate simulations. Often these simulations do not enjoy the advantage of having common computer languages and formats in their working files. Transfers of data between models can become a tedious effort and divert valuable time from analytical efforts. In anticipation of this problem, the study team devoted considerable effort toward determining the level of effort required to develop computer assisted data transfer routines to facilitate the interaction of two models common to every methodological alternative--NUFAM and COSAGE. In view of the potential of this project to support integrated analyses over and above this project, that effort will be continued as an independent effort. During the conduct of this study, it was discovered that programers at CACDA had developed a software interface capable of converting the output of chemical or nuclear programs into the proper format for input to a combat simulation model. This interface inputs integrated warfare data to the JIFFY game used for integrated Scores III. The general description of that interface in paragraph M-2 and Figure M-1 are provided as a demonstration of the feasibility and utility of such developments and their potential for decreasing the operational burden in methodological alternatives.

M-2. CHEMCAS-JIFFY INTERFACE. Scores III is a corps level game being fought in a series of critical incidents (usually about 6 hours of combat time each). Integrated warfare data are infused between the play of critical incidents and require the transfer of information between two computers (UNIVAC and CDC). Chemical casualties and a chemical effectiveness factor must be taken from the CHEMCAS Model (UNIVAC, two-word, six-character format) and restructured as input to the JIFFY Force File (CDC, 2 words, 10 characters). A similar operation is required to infuse nuclear attrition data. This transfer of data, if accomplished manually, could add 2 or 3 days to the cycle time between critical incidents and would require the services of at least two analysts. CACDA has developed a data translator which will accomplish this task in a series of three short runs (about 10 minutes each for a corps). The translator interfaces with a working force file (called E3 main) which carries the units played in JIFFY formatted for the UNIVAC computer. The integration of nuclear and chemical data is done in two discrete steps. The nuclear attrition is applied first, and an updated unit population is then used in the CHEMCAS Model to derive chemical attrition and a chemical effectiveness factor. The degradation factor is computed by UNIT/MOPP/manning level and is used to simulate reduced unit effectiveness by reducing the rate of fire for units that have been subjected to chemical attack. This accounts for two of the three translator runs. The third run uses a subroutine of the translator to break down personnel casualties into individual casualties (infantry) and crew casualties (armor and artillery). This run precedes the unit population update used to structure the force for the application of CHEMCAS.



1. Nuclear program is CACDA produced program which uses damage criteria files (derived from JANUS) to develop nuclear attrition data.

2. E3 main is working force file which reflects all units in JIFFY force file.

3. Arrays are templates showing: center of mass of Bn/Regt, location and area of subordinate companies, and mission oriented protective posture (MOPP) by company.

Figure M-1. CHEMCAS-JIFFY Interface

APPENDIX N

QUALITY ASSURANCE

N-1. BACKGROUND. CAA policy requires each study team to establish a quality assurance (QA) program to assure accuracy and reliability of the study results as they are affected by the validity of, and input data to, the applied methodologies. The program is designed to ensure that study results are based on valid data and models. During the course of this project, QA activities were conducted in accordance with that policy.

N-2. PURPOSE. The purpose of this appendix is to summarize the QA activities conducted during this feasibility study.

a. Input Data. The data concerned involve the capabilities and limitations of component simulations used in the development of methodological alternatives. In all cases, the project team members spoke directly with personnel currently or recently involved as analysts, operators, or developers of the models/routines concerned and requested that they provide estimates as to model availability, capabilities, and estimates of resource requirements. These individuals (both internal and external to CAA) were briefed on the intended uses of these models in alternative methodologies and the nature of modifications and interfaces anticipated in relating them to the other components, and these were considered in making their estimates. Additional validation of data was developed by joint participation with members of the Middle East Requirements Analysis study team in evaluating simulations of mutual interest. In the evaluation of the TRM operated in the standalone mode, demonstration runs were made to verify estimates of its capabilities.

b. Study Team Estimates. The single quantitative factor used in the evaluation of methodological alternatives is the estimate of TMM required for methodology development. In many cases, these estimates relate to models still in the final stages of development and to interfaces not formally considered prior to this study. To ensure the accuracy of these estimates, the study team was divided into independent groups to develop initial values. When differences were found, input data were reverified, and experienced analysts/modelers outside the team were consulted to assist in developing the final estimate.

c. Product Review Board (PRB). This feasibility study report was reviewed by a CAA Product Review Board between 18 and 20 May 1981 in accordance with CAA Memorandum 5-2, 15 October 1976.